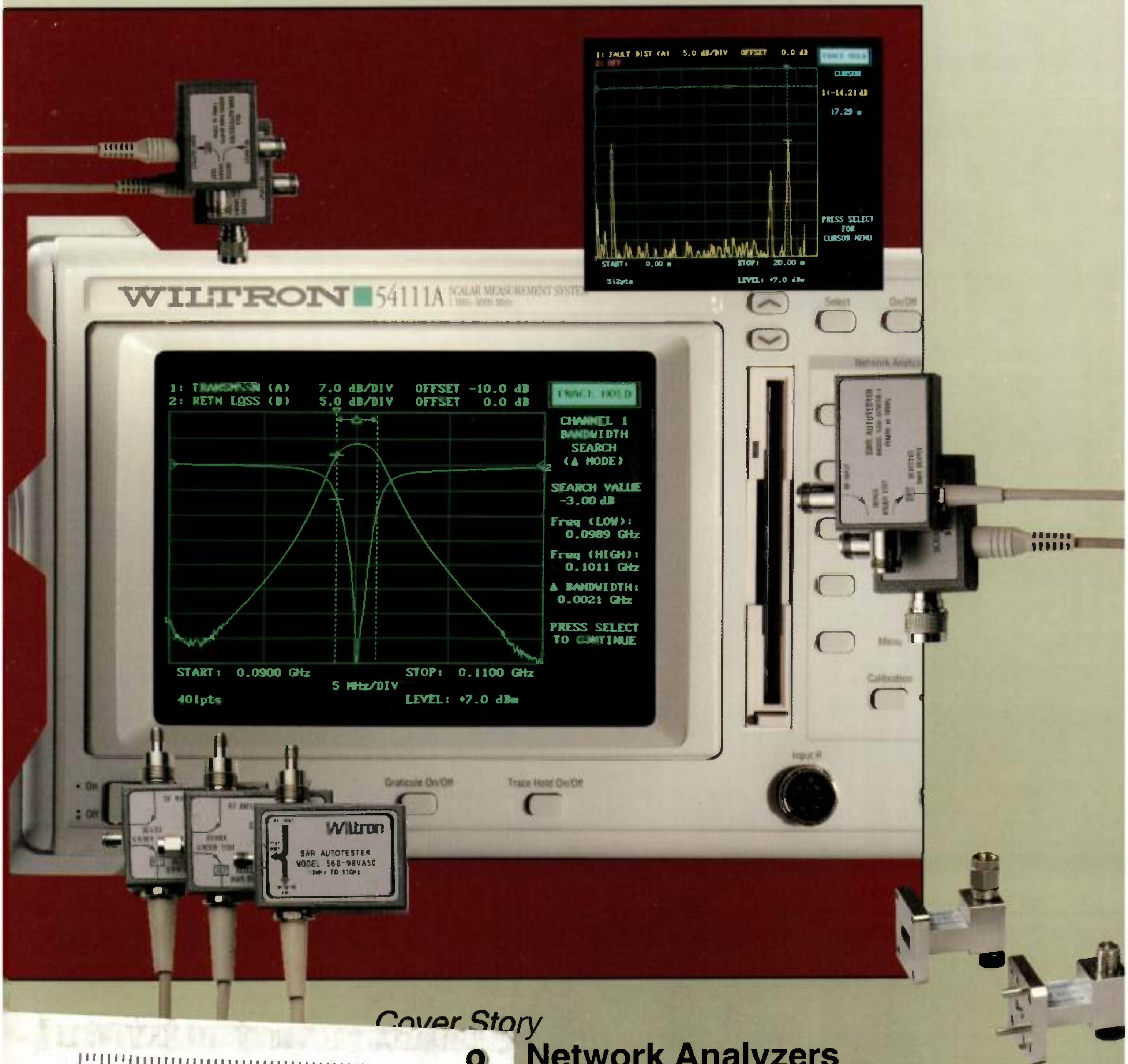
# RF design™

engineering principles and practices

April 1994



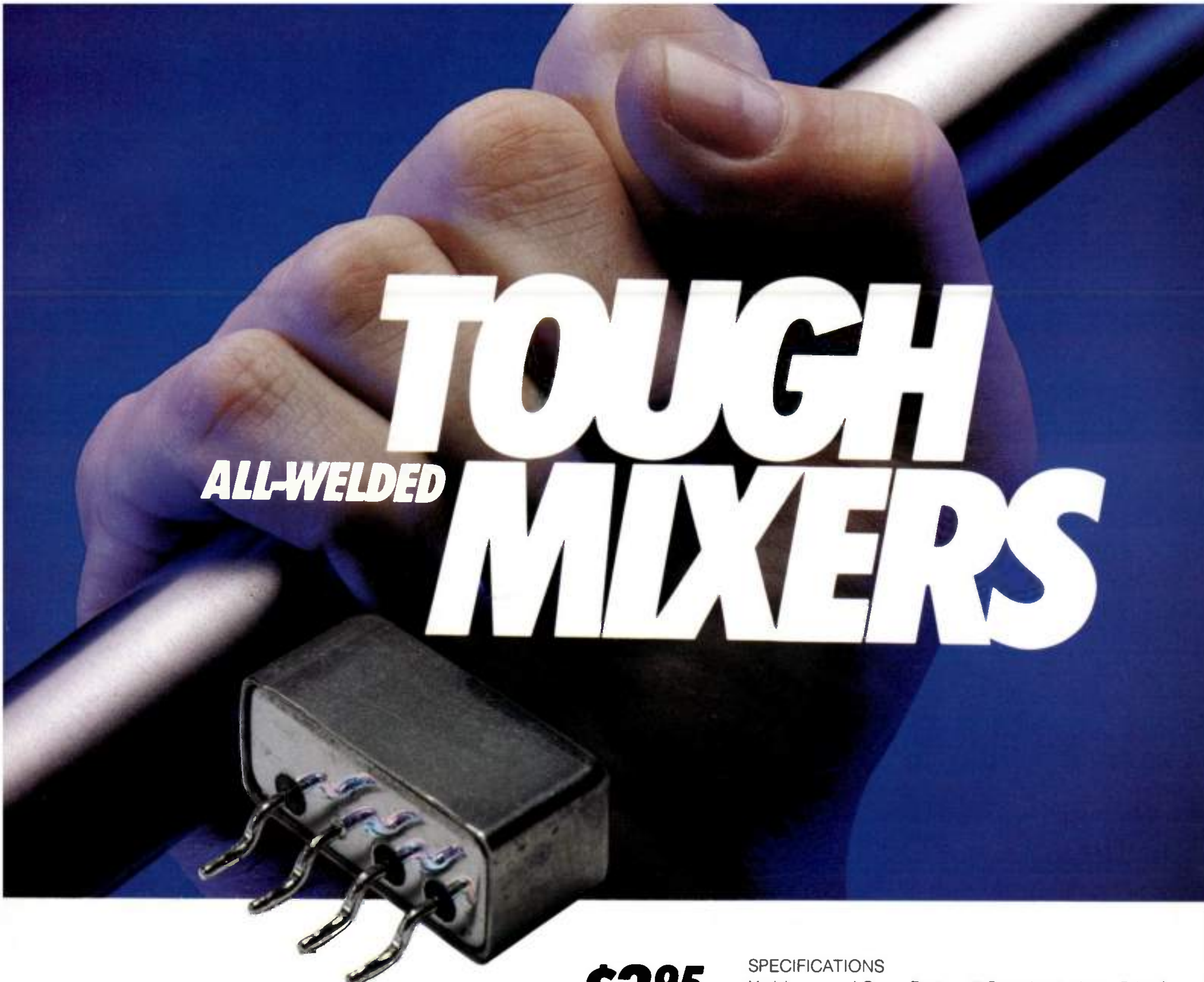

*Cover Story*

**o Network Analyzers**

**shoot Wireless Systems**

*e Technology*

**rated Circuits**

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actual size

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*5-YR. GUARANTEE*

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SPECIFICATIONS

| Model | LO Power (dBm) | Freq. LO/RF (MHz) | ■ Conv. Loss (dB) $\overline{X}$ | $\delta$ | Isol. L-R (dB) | Price,$ Ea. 10 qty |
|---|---|---|---|---|---|---|
| TUF-3 | 7 | 0.15-400 | 4.98 | 0.34 | 46 | 5.95 |
| TUF-3LH | 10 | | 4.8 | 0.37 | 51 | 7.95 |
| TUF-3MH | 13 | | 5.0 | 0.33 | 46 | 8.95 |
| TUF-3H | 17 | | 5.0 | 0.33 | 50 | 10.95 |
| TUF-1 | 7 | 2-600 | 5.82 | 0.19 | 42 | 3.95 |
| TUF-1LH | 10 | | 6.0 | 0.17 | 50 | 5.95 |
| TUF-1MH | 13 | | 6.3 | 0.12 | 50 | 6.95 |
| TUF-1H | 17 | | 5.9 | 0.18 | 50 | 8.95 |
| TUF-2 | 7 | 50-1000 | 5.73 | 0.30 | 47 | 4.95 |
| TUF-2LH | 10 | | 5.2 | 0.3 | 44 | 6.95 |
| TUF-2MH | 13 | | 6.0 | 0.25 | 47 | 7.95 |
| TUF-2H | 17 | | 6.2 | 0.22 | 47 | 9.95 |
| TUF-5 | 7 | 20-1500 | 6.58 | 0.40 | 42 | 8.95 |
| TUF-5LH | 10 | | 6.9 | 0.27 | 42 | 10.95 |
| TUF-5MH | 13 | | 7.0 | 0.25 | 41 | 11.95 |
| TUF-5H | 17 | | 7.5 | 0.17 | 50 | 13.95 |
| TUF-860 | 7 | 860-1050 | 6.2 | 0.37 | 35 | 8.95 |
| TUF-860LH | 10 | | 6.3 | 0.27 | 35 | 10.95 |
| TUF-860MH | 13 | | 6.8 | 0.32 | 35 | 11.95 |
| TUF-860H | 17 | | 6.8 | 0.31 | 38 | 13.95 |
| TUF-11A | 7 | 1400-1900 | 6.83 | 0.30 | 33 | 14.95 |
| TUF-11ALH | 10 | | 7.0 | 0.20 | 36 | 16.95 |
| TUF-11AMH | 13 | | 7.4 | 0.20 | 33 | 17.95 |
| TUF-11AH | 17 | | 7.3 | 0.28 | 35 | 19.95 |

*To specify surface-mount models, add SM after P/N shown.

■ $\overline{X}$ = Average conversion loss at upper end of midband ($f_u/2$)

$\delta$ = Sigma or standard deviation

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INFO/CARD 1

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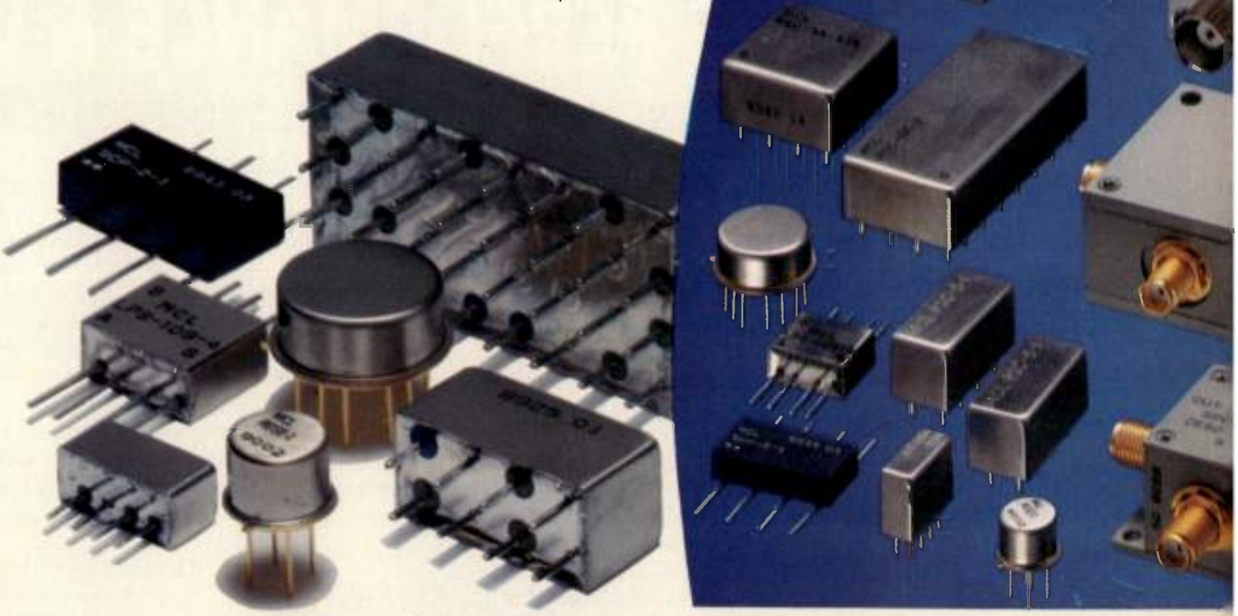

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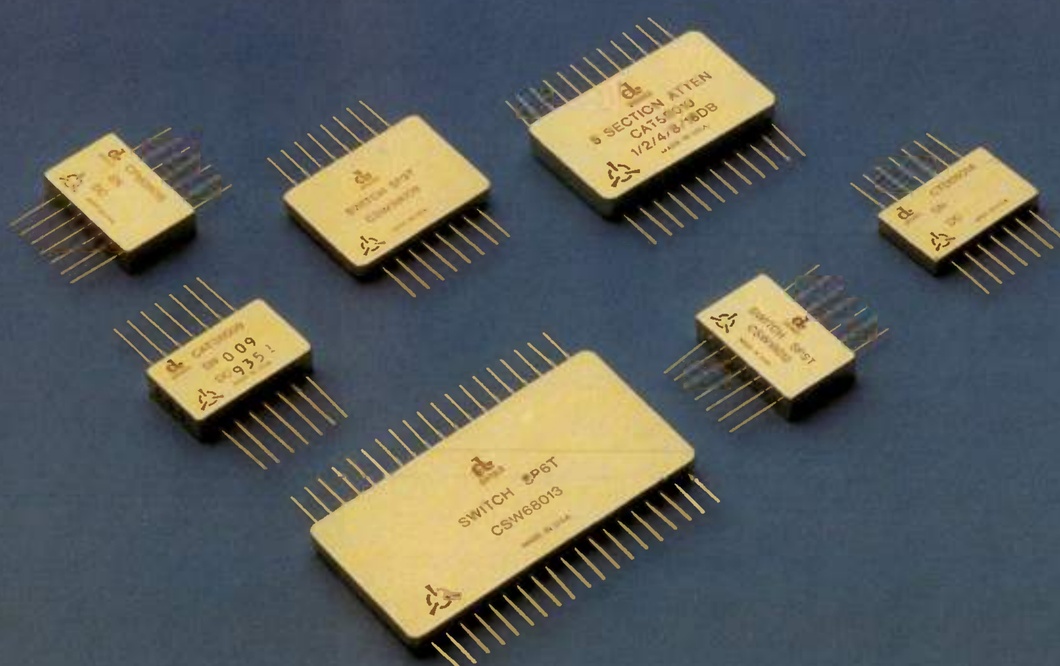
INFO/CARD 3

F134 Rev D

# Leader of the FLATPACK




**Flatpacks**

| Config | Freq MHz | IL dB | Iso dB | Switch Speed n SEC | Part No. |
|---|---|---|---|---|---|
| SPST | 10-1000 | 1.25 | 70 | 35 | 8012 |
| SPST | 400-2000 | 0.9 | 67 | 185 | DS0551 |
| SP2T | 10-1000 | 0.7 | 55 | 40 | DS0860 |
| SP2T | 5-2000 | 1.0 | 57 | 24 | DS02800 |
| SP2T | 5-1000 | 0.5 | 70 | 72 | DS0962 |
| SP3T | 10-1000 | 1.2 | 40 | 100 | 8008 |
| SP4T | DC-2000 | 1.5 | 50 | 30 | CS048024 |
| SP6T | 10-1000 | 0.75 | 50 | 1000 | 8013 |
| 1 Sect Atten | 5-1000 | 0.9 | 10 | 30 | DA0944-10 |
| 1 Sect Atten | 800-1200 | 0.9 | 50 | 80 | DA0879 |
| 3 Sect Atten | 30-300 | 1.0 | .25, .5, 1.0 | 200 | 8009 |
| 5 Sect Atten | 10-400 | 1.7 | 1, 2, 4, 8, 16 | 100 | 8010 |
| Pulse Modulator | 10-1000 | 2 | 80 | 300 | 8015 |
| Threshold Det | 10-3000 | Detects -25 to -10 dBm | | — | 8014 |

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RF design

# contents

April 1994

## featured technology

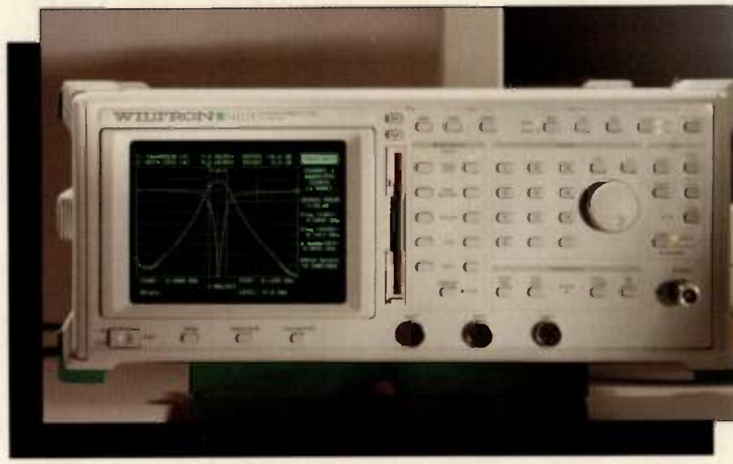

**26 Use Emitter Coupled Logic in Your RF Applications**

ECL is the fastest available logic family, operating a frequencies well into the RF range. Its non-saturated operating mode and high speed make ECL a candidate for both analog and high-speed digital RF circuits.

*— R.N. Mutagi*

**34 New RF ICs and Modules Boost Market Development**

New RF IC and module products are appearing at a rapid pace. Here are some of the most recently announced products from eight companies.


## cover story


**38 Portable Network Analyzers Troubleshoot Wireless Systems**

A new scalar network analyzer series is designed for accurate and flexible field installation and service support. Measuring transmission loss, return loss and SWR establish system performance, while distance-to-fault capabilities allow precise identification of problem components.

*— Ken Harvey*


## tutorial


**48 A First Introduction to Direct Sequence Spread Spectrum**

New wireless applications use this technology to provide resistance to interference and allow re-use of the spectrum. This article is an entry-level intrduction to the characteristics of direct sequence spread spectrum, and methods used for its implementation

*— Gary A. Breed*


## design awards


**52 NPOLE Helps Design Phase-Shift Networks**

This article describes a method, and accompanying computer program, for the design of allpass networks that are used to form constant phase difference networks.

*— R. Dehoney*


## departments


**8 Editorial**
**14 Calendar**
**16 Courses**
**18 News**
**22 Industry Insight**
**42 New Products**
**58 Product Report**
**60 Marketplace**
**63 New Software**
**63 Advertiser Index**
**64 New Literature**
**65 Company Index**
**68 Info/Card**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RF editorial

# How to Find RF Engineers When There Aren't Enough to Go Around

*By Gary A. Breed*
*Editor*

There is a puzzling contradiction in the engineering community — there are too many unemployed engineers, but industry believes there is a shortage of engineers! This is a subject I've noted before, but it needs to be brought up again.

First, without question, a lot of engineers are out of work or working at non-engineering jobs. Places like Los Angeles, Boston and Long Island have relied on military contractors for much of their engineering employment, and now many good engineers are on the unemployment roles.

It is also without question that companies looking for engineers are not finding what they want. The skills that are needed today (fast development, low cost design, design-for-manufacturing, integrated digital/RF systems) are relatively new, and there is only a small pool of existing talent to draw from.

Compounding the problem, because these demands are new, only a few engineering schools have professors with the experience to teach these subjects well. And because these skills represent a specialty, they are addressed in graduate programs, adding at least another year to the pipeline that supplies new engineers.

So, what can industry do to get the engineers it wants, without having to wait for the development of the skills that it demands? The answer is simple in concept, but difficult to accomplish — find those engineers within the existing ranks of the profession who have the potential to learn these skills quickly.

As I see it, this is the only choice that a growing communications industry can make if it wants to accomplish the ambitious goals that have been touted with such public hoopla — from the business section of your local newspaper to TV ads during the Super Bowl.

The difficulty lies in identifying raw talent in an engineer with lots of experience in specific areas. The most obvious way to begin is to see if his or her employment history has variety. Then, was that engineer successful in each of those varied responsibilities?

A set of screening questions can help, designed to identify the engineer's grasp of important concepts like modulation and occupied bandwidth, manufacturing tolerances and yield, or just familiarity with commodity-type RF components (not just high performance stuff).

This kind of analysis takes time, and it takes an engineer to do it. Personnel staff can only do the most fundamental screening; it will take an engineering manager to dig far enough into a prospective employee's experience to find latent talent. That is an expensive proposition in terms of man hours, but it may be necessary.

We inside the industry know that good RF engineers don't grow on trees! With new applications growing fast, the branches are pretty bare. I wouldn't want to be an engineering manager looking for RF engineers right now — it's guaranteed to cause headaches.

But if the need is great enough, some extra effort may help you spot an engineer who doesn't have the right experience, but learns fast and knows how to successfully complete projects.

# RF design

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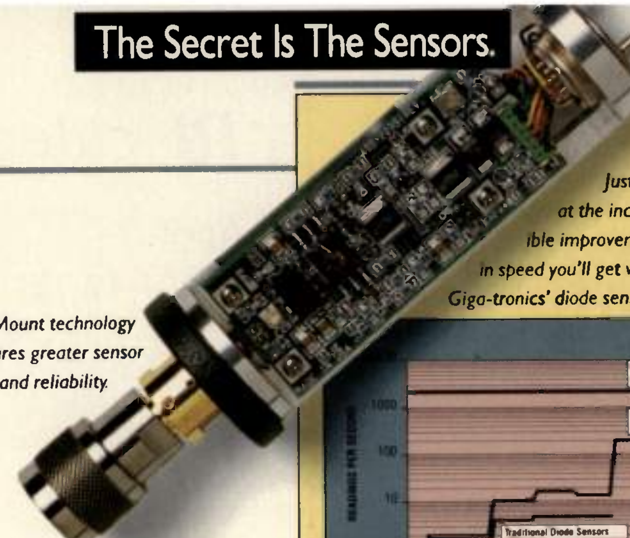
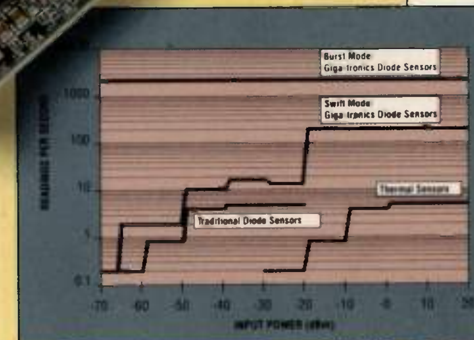


*Surface Mount technology assures greater sensor accuracy and reliability.*

*Just look at the incredible improvement in speed you'll get with Giga-tronics' diode sensors.*




You'll be confident of your peak power readings, and still have all the benefits of an incredibly fast CW power meter.

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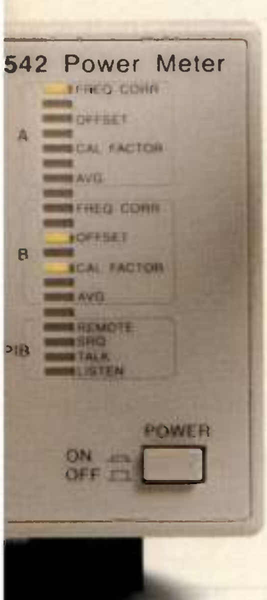


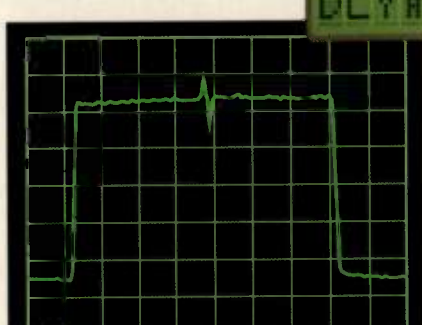

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INFO/CARD 9

# RF calendar

## April

**12-15** **EMC/ESD International**
Anaheim, CA
Information: EMC/ESD International, Registration Coordinator, 6151 Powers Ferry Rd. NW, Atlanta,GA 30339. Tel: (800) 828–0420. Fax: (404) 618–0441.

**20-27** **International Workshop on Computer-Aided Modeling Analysis and Design of Communication Links and Networks**
Princeton, NJ
Information: Benjamin Melamed, NEC USA Inc., 4 Independence Way, Princeton, NJ 08540. Tel: (609) 951–2450.

## May

**10-12** **IEEE Instrumentation & Measurement Technology Conference**
Hamamatsu, Japan
Information: Electronic Industries Association, EIA Components Group, 2001 Pennsylvania Ave .N.W., Washington, DC 20006-1813. Tel: (202) 457-4930.

**23-24** **Microwave and Millimeter-Wave Monolithic Circuits Symposium**
San Diego, CA
Information: Richard B. Gold, Pacific Monolithics, 245 Santa Ana Court, Sunnyvale, CA 94086–4512. Tel: (408) 732–8000. Fax: (408) 732–3413.

**23-26** **IEEE/MTT-S International Microwave Symposium**
San Diego, CA
Information: MTT-S Symposium 1994, c/o LRW Associates, 1218 Balfour Drive, Arnold, MD 21012.

**27** **Automatic RF Techniques Testing 43rd Conference**
San Diego, CA
Information: Bill Pastori, Maury Microwave Corp. Tel: (909) 987–4715. Fax: (909) 987–1112.

## June

**1-3** **1994 IEEE Frequency Control Symposium**
Boston, MA
Information: Michael Mirarchi or Barbara McGivney, Synergistic Management, Inc., 3100 Route 138, Wall Township, NJ 07719. Tel: (908) 280-2024.

**1-3** **Virginia Tech Symposium on Wireless Personal Communications**
Blacksburg, VA
Information: Conference Registrar, Donaldson Brown Hotel and Conference Center, Virginia Tech, Blacksburg, VA 24061–0104. Tel: (703) 231–5182. Fax: (703) 231-3746.

**19-24** **1994 IEEE AP-S International Symposium and URSI Radio Science Meeting**
Seattle, WA
Information: Jan Kvamme, Conference Manager, UW Engineering Professional Programs, 3201 Fremont Avenue North, Seattle, WA 98103. Tel: (206) 543-5539. Fax: (206) 543-2352.

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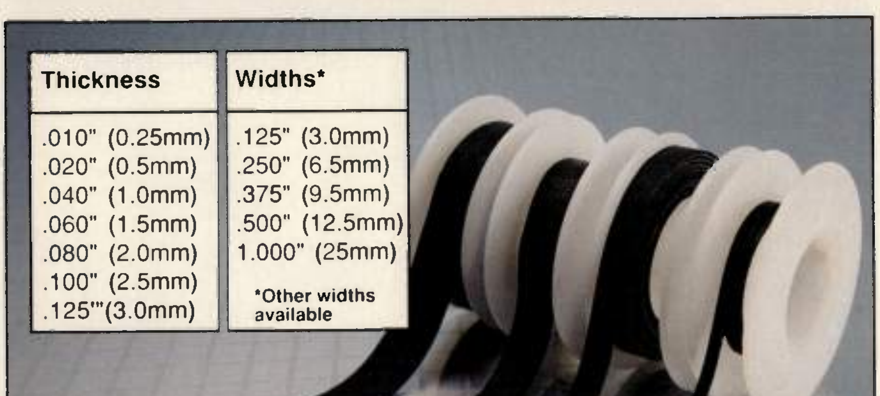

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INFO/CARD 11

# RF courses

**Mobile Communication Engineering**
May 4-6, 1994, San Diego, CA
**Digital Transmission Systems**
May 9-12, 1994, Washington, DC
**Low Earth Orbit Satellite Systems (LEO's)**
May 16-18, 1994, Washington, DC
**Simulation of Communication Networks**
May 23-26, 1994, Washington, DC
**Radio Frequency Spectrum Management**
June 6-10, 1994, Washington, DC
**Global Positioning System: Principles and Practice**
June 7-10, 1994, Orlando, FL
**Digital Transmission for the Cellular Telephone Systems**
June 20-22, 1994, Washington, DC
Information: The George Washington University, Continuing Engineering Education, Academic Center, Room T-308, 801 22nd Street, N.W., Washingto, DC 20052. Tel: (202) 994–6106 or (800) 424–9773. Fax: (202) 872–0645.

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**Circuit Board Level Microwaves: Issues and Solutions**
May 23-24, 1994, San Diego, CA
Information: Tom Laverghetta, TPL Associates, Inc., 516 E. First St., Auburn, IN 46706. Tel: (219) 925–1819.

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**Phased-Array Radar System Design**
April 19-22, 1994, Atlanta, GA
Information: Georgia Institute of Technology, Continuing Education. Tel: (404) 894–2547.

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**Microwave/Millimeter-Wave Monolithic Integrated Circuits**
May 17-20, 1994, Los Angeles, CA
Information: UCLA Extension, Engineerig Short Courses, 10995 LeConte Ave., Ste. 542, Los Angeles, CA 90024. Tel: (310) 825–1017. Fax: (310) 206–2815.

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**VSAT Networks**
April 20-21, 1994, Cambridge, UK
**Satellite Communication Systems**
April 18-22, 1994, Cambridge, UK
**Mobile Cellular and Microcellular Telecommunications**
April 20-22, 1994, Cambridge, UK
Information: CEI-Europe/Elsevier, Mrs. Tina Persson. Tel: (46) 122–175–70. Fax: (46) 122–143–47.

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**Spread-Spectrum Communication Systems & Applications**
May 4-6, 1994, Ann Arbor, MI
Information: Engineering Conferences, 400 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109–2092. Tel: (313) 764–8490.

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**EW Receivers**
May 3-5, 1994, Washington, DC
**Introduction to Radar Systems and Signal Processing**
May 17-19, 1994, Washington, DC
Information: Research Associates of Syracuse, Incorporated, Hancock Army Complex, 510 Stewart Drive, N. Syracuse, NY 13212. Tel: (315) 455-7157.

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## Reports Predicts $10 Billion Phone, Pager Sales by 1999

Frost & Sullivan, a subsidiary of Market Intelligence, is an international high-technology research firm that released a study in January 1994 forecasting a 21 percent compounded annual rate increase in sales for the wireless communications industry. The report, U.S. Cellular and PCS Telephone, Pager and Accessory Markets: Time to focus on Applications, states that sales are expected to increase from $2.5 billion in 1992 to $9.5 billion in 1999. The subsidiary of Market Intelligence said the increase in demand will be coming from healthcare, security and blue-collar businesses, and retail consumers. Though primarily used in business, sales, and service industries up to this point the market is expected to expand in response to declining prices and the motivation for safety and convenience. This will enable families access to the services. Pagers are the biggest growth from the family standpoint. Numeric pagers will keep pace while tone-only pagers will become obsolete. Handheld phones that can be taken out of cars will show the fastest growth. New handsets will offer dispatch and two-way calling capabilities, providing increasingly integrated communications and eliminating the need to subscribe to multiple services. The report said that as individual consumers enter the market retail sales will rise from 22 percent of the total sales in 1992 to 34 percent of the total by 1999.

**Raytheon Developing Zenith Chip** – Raytheon Semiconductor is designing the circuitry for the digital cable transmission system developed by Zenith Electronics Corporation. Raytheon will provide the IF amplifier/demodulation integrated circuit (IC) for digital set-top decoders based on Zenith's 16-level vistigial sideband (16-VSB) transmission system. The system increases the data that can be transmitted on a single cable channel without additional video compression–expanding the expected 500 channels to 1,000.

**U.S., Canada Renew Accreditation** – The U.S. Department of Commerce's National Institute of Standards and Technology and the Standards Council of Canada renewed an agreement on Feb. 22, 1994, that facilitates trade between the world's two largest trading partners. The agreement provides mutual recognition of testing laboratories. For the U.S. that means accreditation by the NIST National Voluntary Laboratory Accreditation Program and for Canada approval by SCC's Program for Accreditation of Laboratories. NIST and SCC base decisions to accredit testing laboratories on similar but not always identical criteria. Both programs meet the requirements of international standards for accrediting laboratories under ISO/IEC Guide 25: 1990—General Requirements for the Competence of Calibration and Testing Laboratories. The operation of accrediting programs under ISP/IEC Guide 58: 1993—Calibration and Testing Laboratory Accreditation Systems-General Requirements for Operation and Recognition, also meets these requirements.

**New ITU Members** – The International Telecommunication Union has brought its membership up to 182 by adding nine new members during 1993. They are: Czech Republic, Georgia, Slovakia, Kazakhstan, Micronesia, The Former Yugoslav Republic of Macedonia, Turkmenistan, Eritrea, and Andorra.

**Microwave Non-destructive Testing** – Flam & Russell, Inc. of Horsham, PA, has received a contract from the U.S. Naval Air Systems Command, Washington, DC. This will allow the transfer of high-resolution microwave imaging technology developed for military use to be investigated for civilian applications. Flam & Russell are manufacturers of custom microwave components, radar, communications and surveillance systems, and specializes in antenna and radar cross-section measurements.

**Middle East GSM Contract** – Motorola's International Cellular Infrastructure Division has signed a $32 million contract with Kuwait's Mobile Telephone Systems (MTSC). The nationwide Global System for Mobile Communications (GSM) system was designed as an open architecture system. This enables network operators to combine equipment from a variety of suppliers. The Kuwait system will consist of Motorola base stations and Siemens EWSD® switches.

**Acquisition of Canadian Company** – Polyflon Company, New Rochelle, NY, acquired Shawinigan Research & Technology Ltd., Nepean, Ontario, Canada lines of Polyguide low-loss clad laminates and SRT bonding film. This gives Polyflon, a manufacturer/processor of components and materials for microwave and RF applications, an ideal material for the commercial antenna market.

**Commercial GPS Sold** – Leica, Inc., Buffalo, NY, has purchased the commercial GPS positioning and navigation systems from Magnavox Electronic Systems Company. According to the Leica Geodesy Business Unit in Switzerland, 40 Magnavox employees will become Leica employees and will work in a newly established facility in Torrance, California. This transaction includes Magnavox's marine and land-based GPS products as well as the company's high-accuracy differential GPS systems, including the ACC-Q-POINT FM-broadcast DGPS network. The sale will not affect the commercial satellite communications business group and in fact will allow Magnavox to focus on its traditional Inmarsat market.

**Tektronix Has Canadian Agreement** – Tektronix Inc. has broadened the alliance, with Rohde & Schwarz GmbH & Co. KG., Munich, Germany, that was announced August, 1993. Tektronix Canada Inc. will assume exclusive marketing, distribution and support responsibility for Rohde & Schwarz' test and measurement, and RF/microwave communications products.

**Superconducting Energy Storage Device** – A three-year $8.6 million federal government subcontract has been signed with Superconductivity, Inc., Madison, WI, for up to five commercial superconducting magnetic energy storage devices (SSD®s). They will improve the quality of power at various military installations. The contract is managed by the United States Air Force (USAF) at McClellan Air Force Base, Sacramento, CA. and is funded by the Defense Nuclear Agency. The SSD® protects sensitive electronic equipment from power disruptions by using a patented superconducting coil that can store electricity without resistance or voltage loss, and can quickly discharge and recharge.

**New Office and a Correction** – Johnstech International moved at the end of 1993 into a new facility but unfortunately they were given the wrong street address which, in turn, was passed on

to the reader. The correct information is: 1210 New Brighton Blvd., Minneapolis, MN 55413-1641. Tel: (612) 338-2020. Fax: (612) 338-2030. Johnstech, a manufacturer of test sockets, also has opened a West Coast office. That address is: 19925 Stevens Creek Blvd., Cupertino, CA 95014. Tel: (408) 973-7215. Fax: (408) 725- 8885.

**Location Change for Monsanto** – The new address for the Metalized Materials of Monsanto's Chemical Group that manufactures shielding products is: 3481 Rider Trail South, St. Louis, MO 63045. Tel: (800) 843-4556. Fax: (203) 854-6034.

**Exclusive Representation for Capacitors** – North American Capacitor Company (NACC) is the sole distributor of Israel's Microelectronics Ltd. capacitors which, effective immediately, will be sold as Mallory/Microelectronics. They sell precision high-powered, high-quality multilayer ceramic capacitors, porcelain chip and leaded capacitors, and variable capacitors. Sample kits are stocked.

**Fil-Mag Acquired** – Technitrol, Inc. (AMEX-TNL) of Philadelphia, PA has purchased Fil-Mag and it will operate it as Fil-Mag, Inc., a Technitrol Company. Fil-Mag designs and Manufactures magnetic components for data and telecommunications networks such as Token Ring and Ethernet. Technitrol is a manufacturer of electronic components.

**RF Supression Products** – Oxley Development Co. Ltd. will open by late spring of 1994 an 11,000 square foot facility that will be dedicated to producing Planar Capacitor Arrays and other dielectric products. The site will be in Ulverston, Cumbria, English Lake District, U.K. An associate company, Oxley Inc., has offices in Branford, CT.

**New Location** – LPKF CAD/CAM Systems is moving to a new location effective March 1, 1994. The new address will be 6040 SW Canyon Drive, Portland, OR 97225. Tel: (800) 345-5753, (503) 297-2720. Fax: (503) 297-2820.

**Sonnet Resumes Marketing of Electromagnetic Software** – Sonnet Software, Inc., of Liverpool, NY, said that the year and a half long marketing and sales relationship with EEsof has been terminated because in September 1993 EEsof was sold to HP. Sonnet, producing electromagnetic software for the analysis of 3-D microwave circuits, will assume all responsibility for marketing, sales, and support of their products.

**Military Contract to Cubic Corporation** – The Electronic Systems Center of the U.S. Air Force awarded a two-year contract worth $12.5 million for eight additional ground data terminals for the Joint Surveillance Target Attack Radar System (Joint STARS). The A.F. exercised the first option of the September 1993 contract and if the second options is exercised the contract would result in the purchase of 27 ground terminals and raise the contract value to $41 million. Cubic Defense Systems developed the jam-resistant Surveillance and Control Data Link (SCDL), which transmits data in real time from aircraft to ground stations.

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INFO/CARD 16

# Dealing with Signal Degradation

By Andy Kellell
Technical Editor

A perfect signal launched into the proverbial "channel" of information theory is always less than perfect when it emerges from the other end. Often the degradation, and its cure, are apparent. Other times, more experimentation is required to find the cause. For example, given a good receiver and a good transmitter, what could be causing third-order audio distortion in an FM broadcast? (The answer to this real-life problem can be found at the end of this report.) This report looks at some of the phenomena that affect particular systems, the tools that allow designers to predict or track down signal degradation problems, and what can be done to directly combat these problems.

The phenomena that affect RF transmissions are as varied as the transmissions themselves.

"Literally thousands of factories in the U.S. are using wireless data communications," says Dr. Theodore Rappaport, Associate Professor and Director of the Mobile and Portable Radio Research group at Virginia Polytechnic Institute and State University (Virginia Tech). RF data communications in factories and offices are most prone to impulsive noise and large dynamic fluctuations in signal strength caused by objects moving in and out of the propagation path, says Rappaport. Fan-blade-modulation and reflection-induced polarization changes are also problems in factory and office RF communication systems says Eric Creviston, a product manager at Teledyne Electronic Technologies.

The phenomena that affect cellular radio transmissions depend on the environment says Scott Kushino, an RF Design Engineer at Cellular One in Denver. "Your concerns in an urban environment tend to be completely different than those in a rural environment, which are different than those in a mountainous environment," says Kushino, "Co-channel and adjacent channel interference are uppermost in our minds when looking at coverage and frequency planning in city areas."

Cable television has its own set of signal degradation phenomena which it must deal with. Micro-reflections originate at every discontinuity in a cable system, and signal leaking into a cable, (called ingress), is also something to be dealt with.

## Modeling and Simulation

Software which simulates RF systems and their transmission paths at various levels is available. Propagation analysis software, like the Terrain Analysis Package (TAP) from SoftWright, integrates geographical information with propagation calculations. Topography information with resolutions as great as 30 meters are available with TAP and it can be used in calculations ranging from line-of-sight calculations to signal strength calculations.

RF systems and their sensitivity to signal degradation can be modeled at the link-budget level with programs such as MIL 3's OPNET Modeler /Radio™. In this program, models of antenna gain, propagation effects, background and interference noise, and transmitter/receiver characteristics can be used to simulate their impact on systems and network performance.

Tesoft's block diagram simulation program, Tesla, simulates circuits in the time domain at the level of filters, VCOs, splitters, etc. Individual blocks can be assembled to form PLLs, modems and complete receivers. "System level design can be quite useful at the debug stage of design because often a difficult problem will have many different potential causes," says Steve Lafferty, president of Tesoft, Inc.

Hardware which helps simulate signal degradation is also available. Arbitrary waveform generators such as Wavetek's Model 395 can simulate baseband or first IF signals undergoing almost any process. "I think the RF market's application for the 395 will be its noise capability. It produces exact, repeatable Guassian white noise," says Bob Ottinger, Design Engineer at Wavetek. Noise-Com's UFX-BER for bit error rate applications is another instrument which capitalizes on Gaussian white noise production capability. By adding white noise to an ordinarily low-noise transmission channel, the UFX-BER allows engineers to measure statistically significant numbers of errors in a short time. The BER calculated at the higher noise level can then be extrapolated to the noise level at which the system normally operates.

Another phenomena which afflicts RF transmission is multipath, and here too, equipment is available which can simulate this effect on the benchtop. Noise-Com's MP2400 can split an actual transmitter signal into12 independently delayed and attenuated signals, which are then recombined at an output port. The amounts of the delays and attenuations can be directly specified, or automatically specified by dynamic simulation of a vehicle's path among a set of reflectors.

## Directly Combatting Degradation

Finally, once the degradation has been identified and quantified, what can be done?

Some techniques attack the source of degradation itself – downtilting cellular base station antennas to avoid transmitting into adjacent cells, for example. Other techniques accept the degradation and work to minimize its effects. There are many different ways of doing adaptive equalization to compensate for micro-reflections, says Doug Greene, Senior Satellite Video Engineer at Jones Intercable. "The equalization we use depends on the modulation we use," says Greene, "This is all cutting edge and we're trying to find out what works best in our environment."

Signal degradation effects every RF transmission system built, but it effects each system in its own specific way. Engineers have tools with which to attack even the most unique problems.

How was the third order audio distortion problem dealt with? Tesoft's Lafferty reports that Bob Plonka of Harris Broadcast suspected standing waves on the transmitting antenna system. A TESLA simulation showed that direct and delayed signals transmitted by different parts of the antenna system caused a phase shift which varied sharply with carrier frequency. As the audio modulated the broadcast signal, the resulting phase shifts were also broadcast. At the receiver the phase shifts were demodulated as FM distortion. The solution was to improve the SWR on the transmission line leading to the antenna. RF

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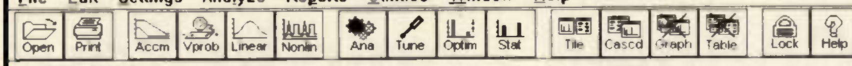


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# Use Emitter Coupled Logic in Your RF Applications

By R.N. Mutagi
Space Applications Centre

*Emitter Coupled Logic (ECL) is the fastest logic device family currently available. It is used in high speed digital logic circuits employed in computers, test instruments and high speed digital communication systems. High speed is achieved in ECL by its non-saturated mode of operation and the low RC time constants maintained in the circuit by the use of smaller resistor values. Due to this, the ECL devices draw high, but constant, currents, eliminating the switching spikes characteristic of TTL. This reduces the system noise. Typical delay for a 10,000 series ECL gate is 2 nanoseconds and the toggle rate for a flip-flop is more than 125 MHz. Because of its non-saturated operation, the ECL can also be used in linear applications. This article shows how a number of communications circuits, which are conventionally built with discrete devices and analog integrated circuits, can be implemented with the ECL devices.*

Communications systems are using more and more digital techniques and technology. These systems invariably employ ECL devices in their implementation. Naturally, if the RF circuits used the same devices as the digital circuits, the system would have many advantages. The number of power supply voltages required is reduced because the linear devices which need a variety of voltages are replaced by ECL devices to achieve the the same functions. The multiple gates within a chip minimize the circuit size and cost. Finally, the circuits built with ECL devices are easily repeatable, are more stable, and can interface with the baseband circuits directly.

Major building blocks of a typical communication system that can be realized with ECL devices are: oscillators, amplifiers, limiters, different types of modulators and demodulators, phase detectors, and frequency multipliers and dividers.

### Gates Work as Amplifiers

ECL OR/NOR gates' switching transfer characteristics have a small input voltage range V during which the output varies linearly. The upper end of this range for which the output just starts limiting its amplitude is about 370 mV. Of this range, about 300 mV is quite linear and has a slope that provides a voltage gain of approximately 3.6. This gain remains constant over a wide range of temperature, (–30°C to 85° C), but the threshold value varies by as much as 50 mV. By biasing the input to the threshold value and applying the signal at this point an amplified signal is obtained at the output.

To obtain a stable bias the threshold voltage can be derived from a gate with complementary outputs [see Biasing ECL for Linear Operation]. In the case of line receivers, where both the differential inputs are biased from a single reference source, the temperature variation does not affect the operation.

Figure 1 shows an amplifier built with quad OR gates (MC10103) for wideband operation at 70 MHz. Three gates are used as amplifier stages and the OR/NOR gate is used to bias them. This circuit provides a minimum gain of 20 dB and a maximum undistorted output (with no current limiting) of about 0 dBm across a load impedance of 50 ohms. A four stage amplifier, shown in Figure 2, is built with the line receivers MC10115 and provides a gain of 30 dB with 0 dBm output across 50 ohms load impedance.

### Amplitude Limiters

Since emitter coupled logic gates operate in a current-limited mode they can be employed in demodulators, such as FM, PM, FSK and PSK, that require constant carrier amplitude. From a single ECL gate, a current-limited output is obtained with a minimum input voltage swing of 350 mV. When the available input voltage level is low, a number of gates can be cascaded to obtain additional gain.

The output voltage swing is limited to the ECL values of –0.9 V and –1.75 V which corresponds to about 0.8 dBm across 75 ohms and 2.6 dBm across 50 ohms. Since each gate has a gain of about 7 dB, addition of each gate in cascade improves the dynamic range of the limiter by 7 dB on the lower end. A three stage limiter starts limiting the signal at –20 dBm. On the upper side, the input can go up to 0.8 dBm, limited only by the device ratings. Thus, a large dynamic range of nearly 21 dB is obtained with a single chip limiter employing three gates.

The transfer characteristics for NOR output shows a droop for increasing

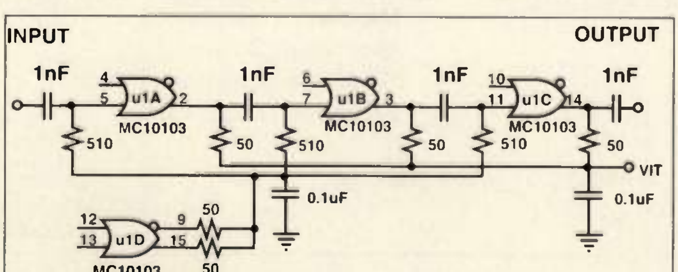


**Figure 1. A 20 dB amplifier implemented with four OR gates. Three provide gain, one is used to bias the other three.**

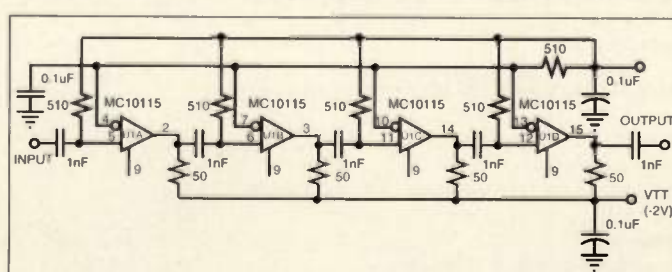


**Figure 2. A limiter built with four line receivers with differential outputs provides about 28 dB gain as an amplifier and has 30 dB dynamic range as a limiter.**

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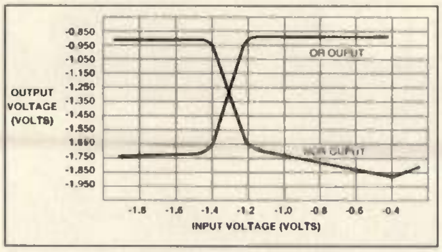



**Figure 3. Transfer characteristic of a typical OR/NOR gate.**

amplitude beyond the linear range (Figure 3). In the limiter applications where the gates are over-driven the input exceeds the linear range and the negative amplitude keeps increasing with increasing input. The transfer characteristics for the OR gate, on the other hand, shows a good limiting characteristics and, hence, is preferred to a NOR gate in limiter applications. The amplifier circuit shown in Figure 2 provides limiting to the signals whose power level exceeds –28 dBm.

## Oscillators

Oscillators are widely used in communication systems for generating the carrier and clock signals, both at the transmitter and the receiver. Crystal oscillators are used for better frequency stability. Voltage controlled oscillators are used in phase locked loops, AFC applications and frequency modulators. In all these applications the ECL 10,000 series gates can be employed for generating frequencies well above 100 MHz. For still higher frequencies the ECL 1600 series or ECL 100,000 series gates can be used. Figure 4 shows a crystal oscillator built with a single OR/NOR gate. The crystal is connected in the feedback path between the NOR output to input which is biased for threshold voltage. The input tank circuit is tuned to the crystal frequency. A second gate is used as a buffer.

## Digital and Analog Modulators

Three types of modulators are used with digital signals: amplitude shift keying (ASK), frequency shift keying (FSK) and phase shift keying (PSK). These are easily implemented with ECL devices. Figure 5 shows an ASK modulator (also known as on-off keyed or OOK modulation). Basically it is an RF switch operated with data. The carrier is switched on and off with the data. Although a single gate could do this switching job, additional gates U1B and U1C are used to eliminate the DC bias in the output waveform (waveforms in Figure 5). The gates U1A and U1B are switching the same carrier, but the output of U1B is wire ORed with the complementary data and hence the outputs at A and B have complementary DC levels on which the carrier burst is superimposed. When these signals are combined at C a DC level equal to the ECL threshold voltage is obtained over which the carrier bursts are superimposed. The output blocking capacitor eliminates the DC and provides a pulsed RF carrier. A single chip OOK modulator provides carrier isolation in excess of 30 dB in the off state.

An FSK modulator shown in Figure 6 employs two oscillators built with NOR gates U1A and U1C. The NOR gates U1B and U1D, with wire ORed outputs, function as a multiplexer, selecting one of the frequencies. The OR/NOR gate (U2A) acts as a buffer to the data and provides complementary outputs which are used as select inputs to the multiplexer.

A biphase shift keying (BPSK) modulator is implemented with a single XOR/NOR gate (MC10107) with one input biased at threshold voltage and the carrier capacitively coupled to it. The data is applied to the other input as shown in Figure 7. A QPSK modulator for 70 MHz operation for TDMA application, implemented with a phase shifter, two D flip-flops and a 4:1 data multiplexer, is described in Reference 2. An extension of this technique is used in the 8-PSK modulator shown in Figure 8.

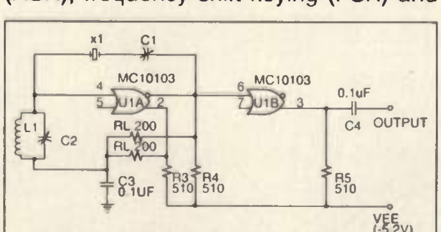



**Figure 4. An OR/NOR gate used as an oscillator. The second gate acts as a buffer.**

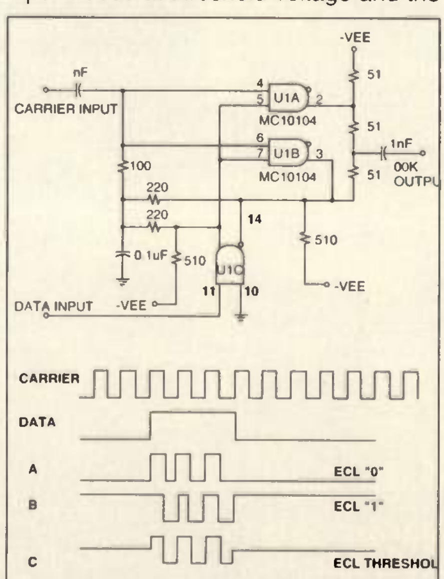



**Figure 5. An AND gate used to provide on-off keying, along with input and ouput signals.**

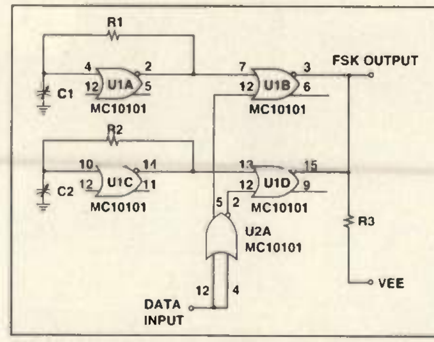


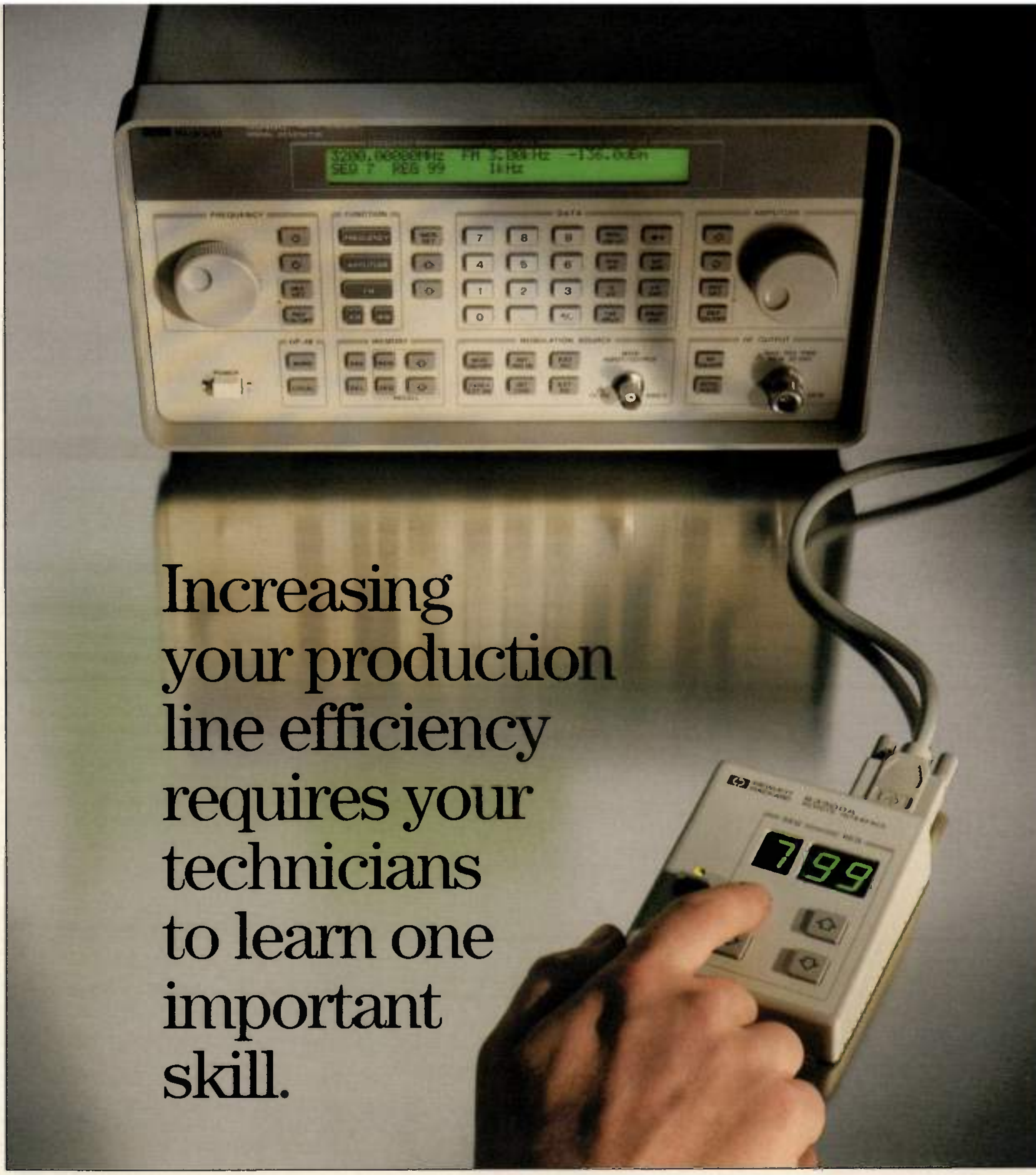

**Figure 6. An FSK modulator implemented with two NOR gate oscillators and a NOR gate 2:1 multiplexer.**

The advantage of this circuit over the conventional circuit employing balanced modulators, drivers and adders etc. is quite obvious. This modulator employs only three phase shifters and three ECL ICs to get 8PSK modulation.

The basic oscillator at $2f_0$, where $f_0$ is the carrier frequency, is also built with an ECL gate as explained earlier. The first phase shifter provides two quadrature outputs which are separately divided by two, with two D flip-flops FF-1 and FF-2. The outputs of the flip-flops are at carrier frequency $f_0$. The first flip-flop is connected in toggle mode with its $\bar{Q}$ output fed back to the D1 input. The second D flip-flop has its D2 input obtained from the Q1 output of the first flip-flop. This connection ensures that Q2 always lags behind Q1 with phase of 45°.

The Q1 and Q2 outputs are applied to two quadrature phase shifters to obtain 0°, 90°, 45° and 135°. Each of these signals are applied to OR/NOR gates to get 180° phase shift for each input. Thus, eight phases of the carrier at 45° separation are available from the gates which are applied to a 8:1 multiplexer. The output is a carrier with its phase chosen according to the data bits applied to the multiplexer. This circuit can operate at 70 MHz, a widely used IF frequency, and accept the data at rates in the ECL range.

Besides digital, the ECL devices can be used in analog modulators too. For example, the ECL voltage controlled oscillator, MC1648, can be used for FM



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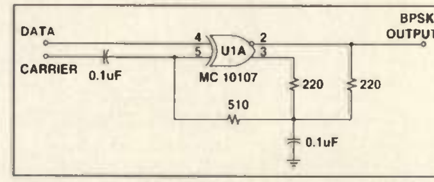


**Figure 7. An XOR gate used as a phase inverter.**

generation at carrier frequencies in excess of 100 MHz. A large frequency deviation with good linearity can be achieved. For example, a peak deviation of ±20 MHz is easily obtained at 70 MHz.

### XOR Gates Double the Frequency

A frequency doubler can be implemented with an ECL XOR gate (MC10107) as shown in Figure 9. The gates G1 and G2 are fed with input signal of frequency f through a coupling capacitor C1 and the inputs are biased to the threshold voltage. The gates G2, G3 and the capacitor C2 provide a delay to the input which is then applied to the second input of gate G1. At the output of G1 pulses at each zero crossing of the input appear. The width of these pulses is equal to the delay provided by the gates G2, G3 and capacitor C2. These pulses have a frequency of 2f. The fundamental frequency is then selected by the notch filter formed by L1 and C3. For input frequencies exceeding 150 MHz MC1672 XOR gate can be used for G1 and single gate can replace G2 and G3.

### Mixers and Dividers with Flip-Flops and Counters

ECL counters provide frequency division by any value. When the division factor is an even number it can be implemented in two stages. For example, when frequency division by 14 is required, a counter can be used to obtain the division by 7 and then a flip-flop connected in a toggle mode can provide further division by a factor of two. This ensures a square wave output which can be easily filtered to get a sine wave. ECL dividers form the backbone of high frequency synthesizers.

Besides these, there are other functions that can be implemented with high speed ECL devices. An MC12000 D flip-flop can act as a harmonic mixer, and the MC12040 works as a phase detector. These devices find extensive applications in the high speed phase locked loops.

### An Example of ECL Application

A simplified block schematic of a typical QPSK demodulator is shown in Figure 10. This comprises clock, carrier and data recovery branches. A heavy outline marks the blocks that can be implemented with ECL devices, and the suggested

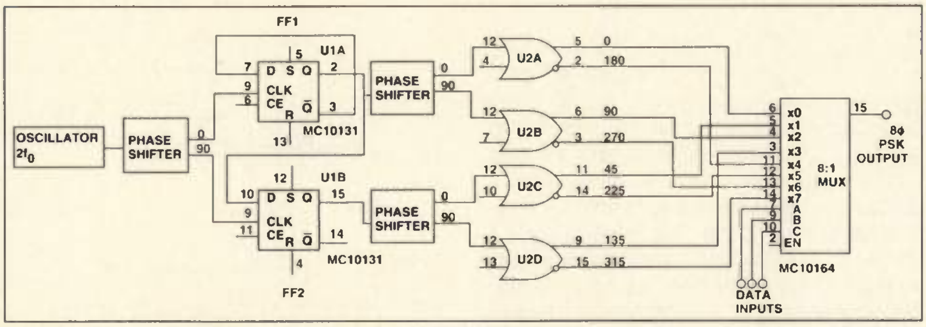


**Figure 8. An 8-PSK modulator built with a succession of phase shifters and a multiplexer.**

devices are given inside.

For clock recovery, the input signal and its one-bit-delayed version are multiplied in a phase detector (MC12040). The output is filtered and shaped in a limiter formed with ECL gates (MC10101). This clock is used for retiming the demodulated data using the D flip-flop (MC10131). For carrier recovery the input signal is multiplied by four, using a set of XOR gates (MC10107) and tuned circuits. The resulting 280 MHz signal is devoid of any modulation. When this signal is divided by four, using two D flip-flops a 70 MHz carrier signal is obtained. Two carriers in quadrature are obtained from the divider itself. These signals provide the demodulated data when exclusive ORed with the input data in the two branches. This data is then low pass filtered, amplified with gates (MC10115), and quantized with threshold comparators (MC1650). The output of the comparators are re-timed as mentioned above to get the I and Q channel demodulated data.

### Basics of Emitter Coupled Logic

The basic emitter coupled logic (ECL) device is a two input OR/NOR gate. This gate's circuit is shown in Figure 11. It comprises two transistors Q1 and Q2 connected in parallel and forming a differential pair with a third transistor Q3.

All the emitters are tied together and connected to the supply voltage $V_{EE}$ through a resistor R5 which acts as a constant current source. The base of the transistor Q3 is held at a temperature compensated, stable reference voltage $V_{BB}$. The bases of Q1 and Q2 are used as inputs and the collector outputs are buffered through emitter follower transistors Q4 and Q5 to provide low impedance outputs. An emitter pull-down resistor R6 is connected from the output to $V_{EE}$. Normally, the $V_{EE}$ terminal is kept at –5.2 V and the VCC terminal is grounded. The corresponding $V_{BB}$ is –1.29 V.

When the potential at the inputs A or B (base of Q1 or Q2) increases above $V_{BB}$, Q1 (or Q2) starts drawing more current from the constant current source. Current through Q3 starts reducing and finally it stops conducting. This change in the collector current flowing through resistors R3 and R4 produces a voltage swing between –0.05 V and 0.98 V. These voltage levels are shifted by the emitter followers to the logic levels of –0.8 V and –1.75 V. These are the typical voltage levels for logic 1 and 0 conditions.

As seen from the transfer characteristics of a typical 10,000 series ECL OR/NOR gate there is a transition range during which the output varies linearly with the input. Although this is a small

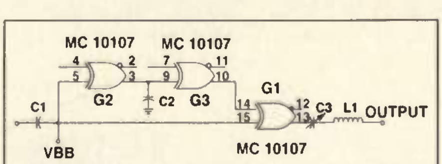


**Figure 9. Two XOR gates and a capacitor provide the delay needed for a third XOR gate to detect data edges.**

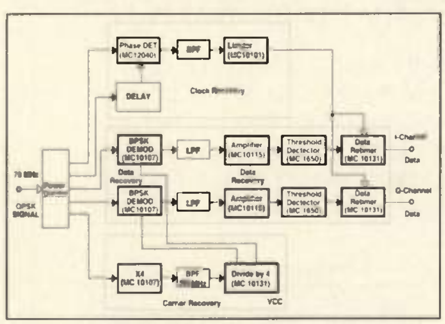


**Figure 10. Block diagram of a QPSK demodulator. Heavier boxes are implemented with ECL gates.**

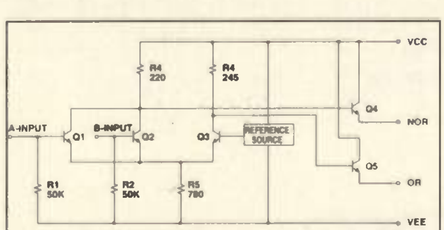


**Figure 11. Schematic of a basic ECL OR/NOR gate.**

range, of about 360 mV, it is good enough for small signal applications.

### Biasing the ECL

The key point in the linear operation of ECL devices is to bias the input to a threshold voltage of –1.29 V. Since this linear range is small, this potential should be held stable as any deviation in this reduces the usable linear range. When a signal of small amplitude is capacitively coupled to the input it is superimposed on the bias, and as long as the input peak voltage is within the linear range, the output is not limited.

When the line receiver gates (MC10115, MC10116) are used the bias voltage is available from an internal stable reference source which is applied to both the inputs of the gate used through equal resistors and the signal is fed to one input through a capacitor (Figure 12a). For other gates, a resistor divider between ground and $V_{EE}$ can provide a threshold voltage. The value of the resistors shown in Figure 12b also provides an input impedance of 50 ohms.

Alternatively, if complementary outputs are available from a gate (an OR/NOR gate for example), the outputs are summed through equal resistors to get the threshold voltage (Figure 12c). This technique provides a stable threshold voltage because the two complementary outputs move symmetrically about their mean, which is the desired bias point.

It is apparent that, except the filters, a large majority of the RF circuits can be implemented with ECL devices. The advantages are in the low cost, small size and lower complexity of the resulting system. A possible disadvantage is the increase in the power dissipation. *RF*

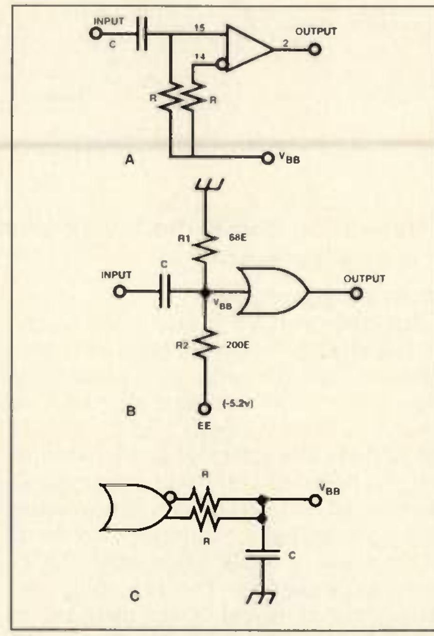


**Figure 12. Three ways of obtaining an ECL threshold bias voltage using ECL gates.**


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1. *MECL System Design Handbook*, Motorola Inc., 1971.
2. R.N. Mutagi, "Digital Replaces Analog in Simple QPSK Modulator," *Electronic Design*, March 4, 1982.


### About the Author

R.N. Mutagi is in the Baseband Processing Division of the Indian Space Research Organisation's Space Applications Centre. He can be reached at SAC P.O., Ahmedabad-380 053, India.

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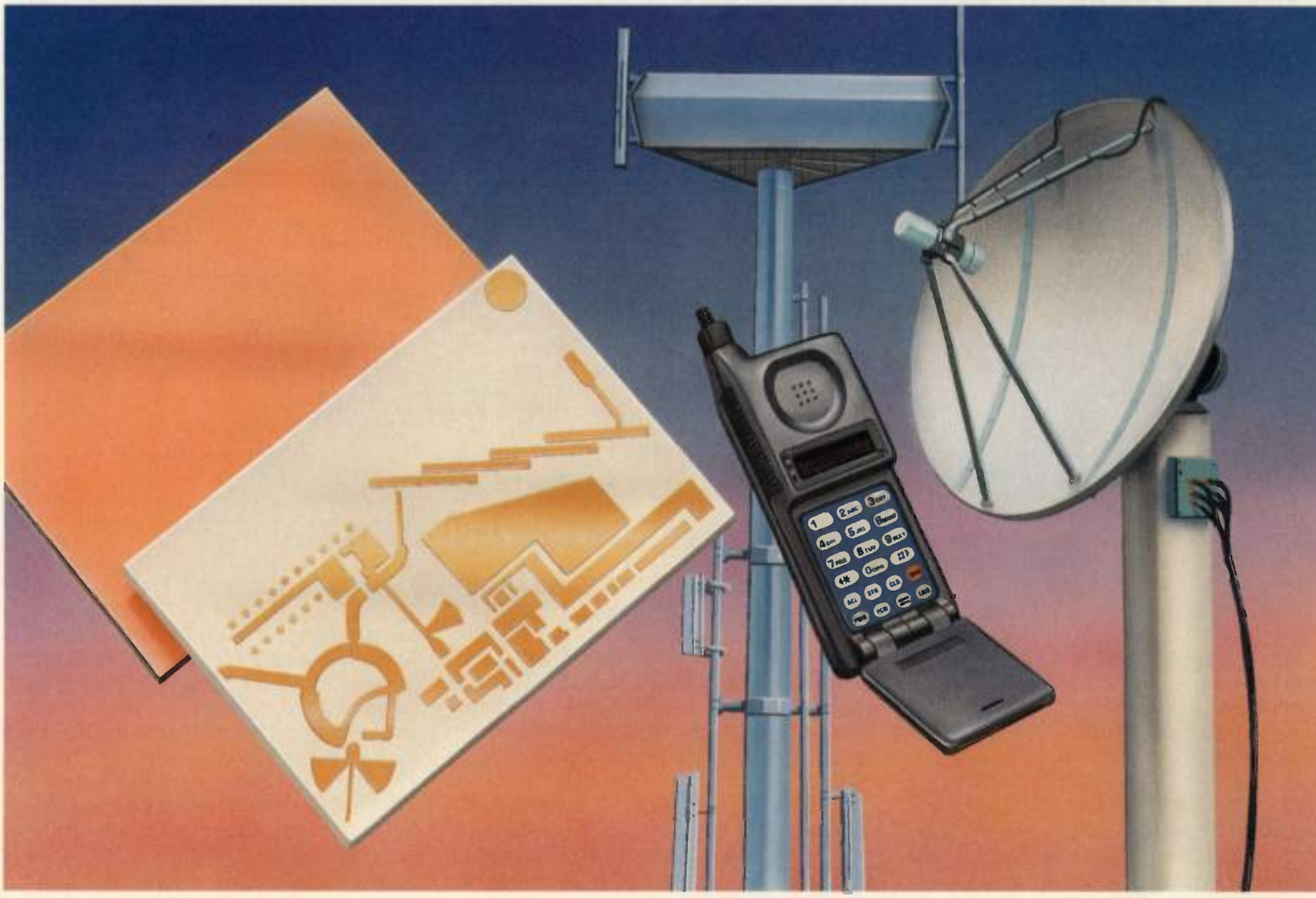

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# New RF ICs and Modules Boost Market Development

*This month's Featured Technology highlights RF ICs and modules. Normally, we include two or three technical articles on our featured topic, such as the preceding article on ECL applications. But this month there are several important new product introductions, and we decided that it was most useful to cover them in this special report. Next month, we will return to our usual format of technical articles for our Featured Technology subject.*

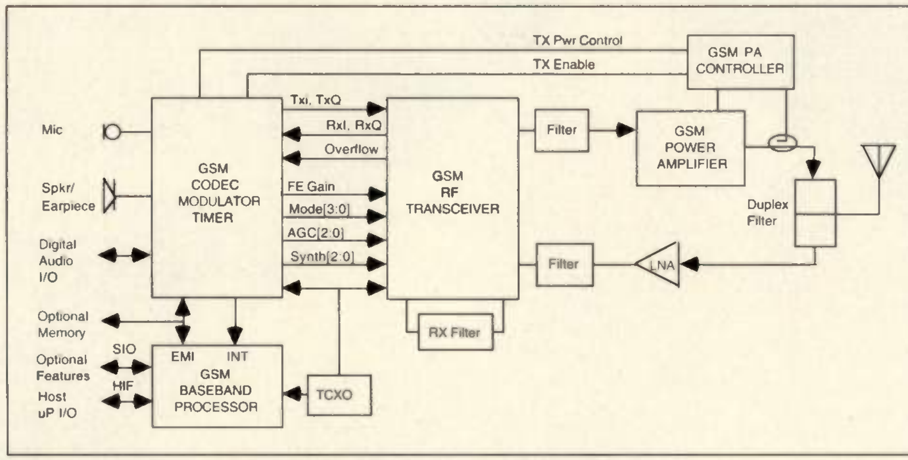


**Figure 1. Block diagram of the AT&T GSM chipset.**

## AT&T Announces the Sceptre™ Chipset for GSM

A highly integrated chipset for GSM digital cellular telephones has been announced by AT&T Microelectronics. Dubbed Sceptre, the chipset (Figure 1) includes five ICs that perform all microphone-to-antenna functions. Additional major active components include a TCXO frequency reference, receive low noise amplifier and the system microcontroller. Additional passive components include the front end diplexer and the IF filter.

Baseband processing is handled by the DSP 1618, together with the Conversion Signal Processor, 3-volt devices which perform all audio processing, and baseband processing that delivers the proper GSM-compatible modulated I and Q signals to the modulator, and accepting similar I and Q signals from the demodulator.

The most highly integrated RF device in the shipset is the W2020 Transceiver, which also operates from a 3-volt supply. This IC includes a frequency-agile UHF synthesizer as the main frequency control element, plus two fixed-frequency synthesizers that generate up- and down-conversion local oscillator signals. The receive path includes an RF mixer, digital gain-controlled IF amplifier, and quadrature demodulator. The transmit path includes an offset oscillator, mixer and quadrature modulator with an accurate 90 degree phase splitter. Only one IF filter is required for both the transmit and receive paths.

A two-chip power amplifier section was used to take advantage of the performance of GaAs and the economy of silicon technology. The PA is a three-stage GaAs IC amplifier with output power up to 2 watts, working in conjunction with a silicon power controller IC to meet the GSM power output mask. The controller also provides the negative gate bias voltages required by the PA, eliminating the need for a separate DC-DC converter.

The baseband and DSP devices are packaged in 100-pin TQFP packages, the transceiver IC is provided in a smaller 64-pin TQFP. The power controller is in a 20-pin SSOP, and the PA uses a 20-pin PSOP (power small outline package) that includes a metal bar on the underside of the package for improved heat dissipation.

## New Driver, Downconverter and LNA from TriQuint

TriQuint Semiconductor recently announced three new GaAs ICs for portable applications. The TQ9203J downconverter (Figure 2) offers a 2.7 dB noise figure, 20 dB system gain, and conversion from the 800-1000 MHz range to an IF of 30-200 MHz. 10.5 mA power consumption from a single +5 volt supply is an attractive feature. The IC also includes internal switching between two inputs, allowing two different LNAs to feed the receive system. Pricing in large quantity for OEMs is around $4.00.

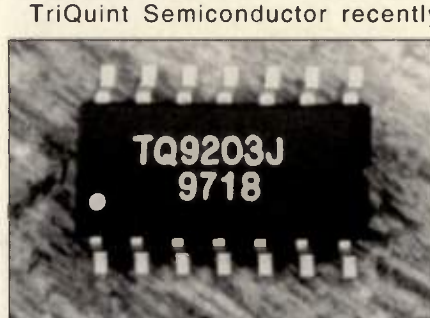


**Figure 2. The TQ9203J downconverter in a SO-14 package.**

Two amplifier ICs have also been introduced. The TQ9122N is a low noise amplifier for 500-2500 MHz, provided in a SO-8 package. Specifications include 25 dB gain at 1575 MHz, under 1.5 dB typical noise figure, output matched to 50 ohms, and 18 mA supply current from a +5 volt supply.

A driver amplifer covering 800-2500 MHz provides 50 mW power. The TQ9132N has 17 dB gain at 2000 MHz, input and output matching to 50 ohms, and operation from 3 to 5 volts with 90 mA current drain. Both amplifiers are about $3.00 in OEM quantities.

## ITT Debuts GaAs Power Amplifier for Single 3.3 Volt Supply

The ITT Gallium Arsenide Technology Center (ITT GTC) has developed a series of power amplifiers for DECT, PCS and AMPS applications. The ITT332201BD delivers 500 mW in the 1880-1930 MHz band, with 24 dB mini-

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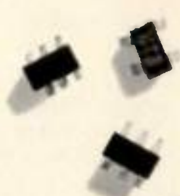

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7.5 mA Icc

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19 dB Gain
2.8 dB NF
6 mA Icc

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**Wide Band Amplifier**
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3.5 dB NF

**UPC2713**
**Wide Band Amplifier**
DC to 1200 MHz
29 dB Gain
3.2 dB NF

**UPC2723**
**AGC Amplifier**
100 MHz to 1100 MHz
38 dB AGC
13 dB Gain

**UPC2721**
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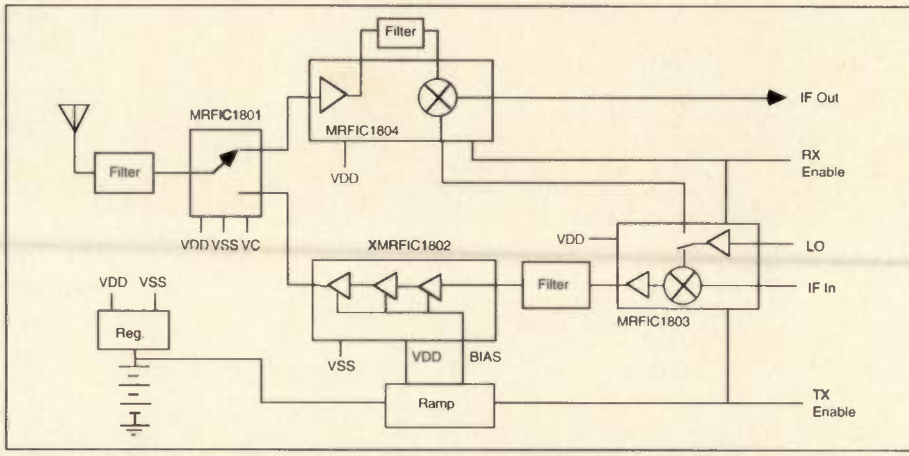


**Figure 3. Block diagram of the Motorola PCS/PHP RFIC1800-series.**

mum power gain. The ITT332202 covers 1700-1900 MHz with similar specifications. For AMPs cellular, the ITT332101 provides 1 watt ouptut over 824-849 MHz with 30 dB minimum gain.

3.3 volt single-supply operation is the primary feature that ITT is promoting, and these specifications are all referenced to operation at that voltage.

All these GaAs power RFICs are matched to 50 ohms input and output, with very minor compensation necessary to obtain optimum performance. The devices are packaged in a power 16-pin SOIC which dissipates heat via the lead frame and wide ground pins.

### Motorola Targets PCS and PHP With New GaAs RFICs

Three new RFICs are available, and another is in final development for the RF functions in the 1.8-2.5 GHz bands. The MRFIC1801 antenna switch will handle 2 watts in the 1.5-2.5 GHz range, the XRFIC1802 developmental power amplifier produces 500 mW in the 1.8-1.95 GHz range, the MRFIC1803 upconverter brings the IF up to an operating frequency of 1.7-2.5 GHz, and the MRFIC1804 LNA/downmixer offers 2.3 dB noise figure and 18.5 dB conversion gain for translation of 1.8-1.925 GHz signals to an IF of 70-325 MHz.

The devices are all designed for 2.7 to 3.3 volt operation, although the power amplifier and antenna switch ICs require a negative bias supply. All are provided in SOIC packages for economical high-volume manufacturing. The chip set includes all signal path functions between the IF and the antenna. Figure 3 is block diagram of the family.

### RFICs from Temic Designed for UHF Data Transmission

A family of low-power UHF receiver ICs from Temic Telefunken Microelectronics initially addresses automotive security systems, wireless LANs and houshold appliance controls. Typically operating at 433 MHz, the U 431X B family features 1 mA standby current for power savings in battery-powered systems. The receiver IC family is suitable for either AM or FM data transmission, using an integrated log amplifier for AM demodulation and a quadrature detector for FM. Data recovery is accomplished

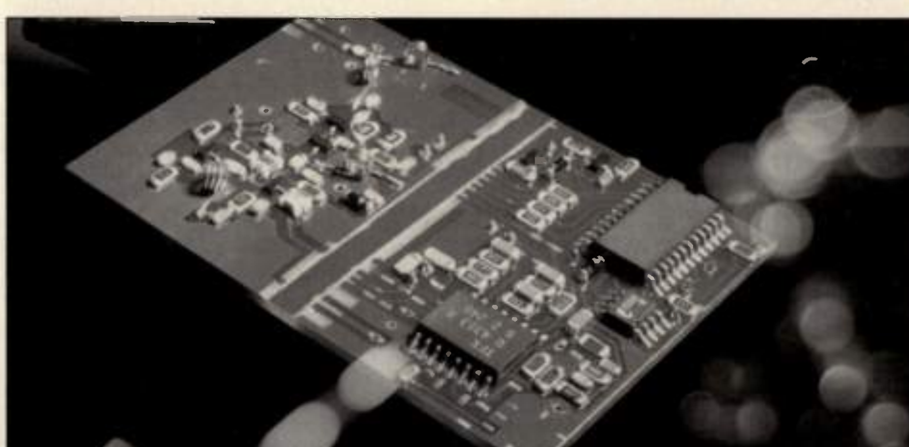

**Figure 4. Data transmission for UHF remote control systems are the applications targeted by TEMIC's low power receiver ICs.**

with a clamping comparator and operational amplifier. In 1000s, the U 431X B is priced at $2.72. Figure 4 is a photo of a receiver board using the device.

### MOSFET RF Power Modules from Hitachi Aim for Cellular Phones

Hitachi America offers four new MOSFET-based RF power modules for analog (AMPS) and dual-mode (AMPS + IS.54 and AMPS + IS.95) cellular phones. The use of MOSFETs offers high efficiencies and linearity, and single-voltage power supply operation. Gate bias characteristics of MOSFETs permit simplified power control, with no separate path for shutdown.

The PF0045 covers AMPS analog cellular with 1.2 watts output and 6 volt supply requirements. The PF0045A is a 4.8 volt version. For digital cellular, the PF0210 provide 6.0 watts from a 12 volt supply, and the PF0231 delivers 0.6 watts with a 6 volt supply requirement.

### Analog Devices Shows First Product from RF Group

The recently-formed RF group at Analog Devices has introduced the AD831 500 MHz mixer. Readers interested in this device should see our New Products section on page 42.

### Hewlett-Packard Promotes High Integration Capability

The Components Group of Hewlett-Packard has announced a developmental RFIC featuring a high level of integration. The RFIC is a modulator/transmitter chip with on-chip frequency synthesis functions, quadrature modulator and image-reject upconversion. *RF*

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# Portable Network Analyzers Troubleshoot Wireless Systems

*By Ken Harvey*
*Wiltron Company*

*Efforts to increase the capacity of automotive cellular, PCN/PCS, wireless PBX, wireless cable television, and wireless LANs are pushing specifications beyond the standards of existing analog system transmission components and installation procedures. The need for higher performance test requirements is answered by classical trouble shooting techniques supporting microwave cabling tests in US military avionics test systems. This article introduces the 54111A Scalar Measurement System, which can easily identify, isolate, and document SWR performance from 0.001 to 3.0 GHz using a low –60dBc harmonic signal source, high 40 dB directivity SWR Autotesters, FFT based distance-to-fault software with resolution to better than 0.1%, and an integrated 1.44 Mb DOS disk drive.*

New wireless digital communication systems are being designed for optimum system capacity. As new digital speech compression codes and bandwidth efficient modulation techniques have evolved, the high frequency performance limitations of cables, connectors, antennas, and installation procedures used in existing analog systems becomes an increasingly important factor in maintaining adequate transmission quality.

Competition, aggressive component suppliers, restricted capital budgets, and simple bargain hunting can often leave RF engineers and telecom purchasing departments in a dilemma — purchase marginal products at a bargain price or pay the premium for top quality components. Combined with tight schedules and modestly trained third party installers, system engineering teams responsible for proper system coverage are rightly concerned.

Furthermore, as operating frequencies increase, component specifications are increasingly difficult — and more expensive — to achieve. Will the base station system pass installation tests and continue to fulfill regulatory requirements? Will the cell site's coverage areas contract and expand intermittently as poor cable connections are rattled by storm winds?

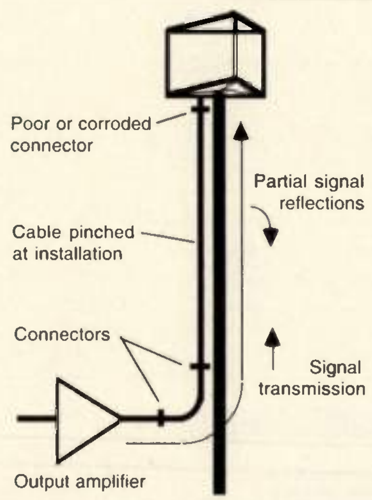



**Figure 1. Transmission line faults and almost all antennas reflect some transmitter energy back toward the source.**

| Cable Problems |
|---|
| Cable Discontinuities |
| Braid Wire Ground Shield Fault (Appears As A Notch Filter ) |
| Damaged/Cut Ground Shields |
| Dielectric Fault or Narrowed Dielectric Diameter |
| Fasteners Pinch Cables |
| Connector Problems |
| Low Quality Connectors |
| Connector Pin Offset (Poor Mating Contact) |
| **Antenna Problems** |
| Antenna Out Of Specification |
| Antenna Storm/Shipping Damage |

**Table 1. Common cable and antenna faults that can cause excessive transmitter power reflection.**

## Identifying SWR Problems

Most RF components have one critical specification in common — input SWR (often specified as return loss). Since every component in a transmission system will reflect some of the transmitter's signal energy, RF system engineers must specify each component's contribution to the transmission system's overall SWR specification.

One obvious drawback of excessive reflected power is reduced output power and coverage area. Usually the output power reduction is less than 1.0 dB and is therefore inconsequential: the system will still operate without noticeable degradation. However, some surprisingly common, and difficult to diagnose, problems can cause excessive out of channel emissions. If left uncorrected, some transmission line installation problems will eventually degenerate into intermittent or complete failure.

Excessive reflected power will load an unisolated transmitter amplifier. The initial symptoms appear as a slight adjacent channel interference problem or a third order intercept problem that is particularly difficult to bring into tolerance, even when the transmitter is replaced.

If the transmitter amplifier has output isolation, reflected power from transmission line connector faults will be reflected again by the isolator causing a delayed interference signal which has effects similar to multipath fading. Depending on the level of the reflections, this can produce excessive random phase distortion as the vector phase of the various reflections combine with the desired output signal constructively or destructively as a function of instantaneous phase.

## Failure Causes

Improperly installed connectors are difficult to identify because they may be marginally acceptable at the time of installation, but degrade over time. The performance deficiencies of poorly tightened connectors, incorrect connector pin offsets, and poor environmental seals of shields are exacerbated by acid rain and normal metallic corrosion. Eventually, these problems cause intermittent outage and failures at exactly the times they are least welcome — during thunderstorms or during periods of extreme cold. These are some of the reasons high quality digital systems such as GSM and DSC 1800 have strict requirements on connector types, pin depth tolerances, torque loading, and installed system return loss.

These problems are apparent only during the installation stage rather than on the engineering bench or during normal incoming inspection tests. Fortunately, however, the most common of these failure conditions (See Table 1) are easy to fix, if the problem is diagnosed and isolated by the test system.

## Adapting Military Techniques

Some characteristics of test equipment developed for US military usage such as high cost, large mass, and 40 GHz frequency range are undesirable in RF applications. However, other attributes such as high accuracy, rugged construction, fast setup, and single button operation are a good fit for field testing wireless RF systems.

Microwave manufacturers and military organizations utilize scalar network analysis systems on the bench top and in the field for several reasons. First, since scalar measurement systems are designed specifically for measuring return loss and transmission loss of components, they are easy to use, accurate, and require a minimum of setup time.

Second, they're about half the price of, and considerably more rugged than, vector network analyzers. Thus, scalar systems are used for both depot component tests,and flight line tests that quickly determine the return loss performance of on-board aircraft cables and waveguides. Measured data is then compared to previous data to identify any changes, that is, changes indicating loosened connectors or other damage.

## Saving Time

Finding loosened connectors (quite common in EW and radar equipment) and other transmission line problems saves time for two reasons. First, the high resolution allows technicians to easily identify which side of a bulkhead should be opened to gain access to the loose or corroded connector. Second, automated test systems would fail due to the transmission line problem. Test procedures would then prescribe removal and replacement of an entire module — which, of course, would later prove to be operating properly. Worse yet, modern logistics support systems frequently send the supposedly defective modules back to commercial repair centers, causing an unnecessary repair bill. How many times have you seen "No Problem Found" on a repair report? Finding the problem in a cable or connector prior to module removal avoids this unnecessary effort and expense.



INFO/CARD 30

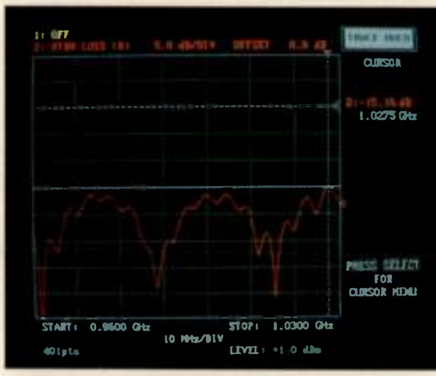


**Figure 2: This swept frequency plot of a transmission line cable and antenna marginally meets the –15 dB return loss specification.**

**Figure 3: A distance to fault measurement reveals that the second connector is the source of excessive reflection.**

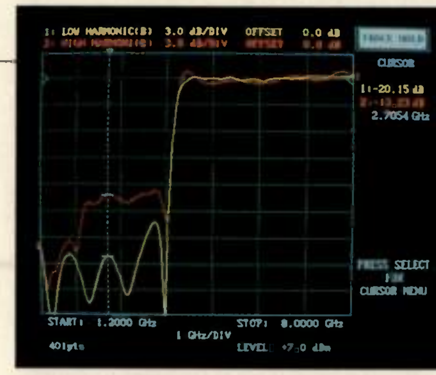


**Figure 4: The actual return loss of this low pass filter is grossly distorted by a source's excessive second and third harmonics.**

### Finding Faults

The same basic measurement principles which were used for measuring microwave waveguide and coaxial transmission systems are now being applied at 0.001 to 3.0 GHz. Today, these transmission line test systems are lighter, self contained, easier to operate, and sell for about one third the cost of even the least expensive microwave test systems.

The Wiltron 54100A Scalar Measurement Systems provide a simple means of verifying the transmission line and antenna system performance during installation and at regular maintenance intervals (Figures 2 and 3). Over the past twenty years, the US military has used a two step process which:

1) Identifies the presence of a coaxial (or waveguide ) transmission line problem with precision SWR Autotesters

2) Isolates the exact position of the fault using an FFT translation of the swept frequency reflection characteristics to distance (time domain factored for speed of propagation).

The Wiltron 54100A Series continues to provide these capabilities in microwave regions and also dramatically reduces the cost for RF systems with lower frequency components and sources to 1.5 GHz, 2.2 GHz, 3.0 GHz, and 8.6 GHz.

### Distance-To-Fault Test Operation

First, a low harmonic source with better than –40dBc harmonic levels and a precision SWR autotester (35 to 40 dB directivity) are used to accurately measure the return loss of the microwave cables (see Figures 4 and 5).

If the SWR is out of specification, the problematic connector, cable, or antenna is quickly isolated with an automated FFT based distance-to-fault location technique. The principal is similar to airline techniques which are used to extend the directivity of standard SWR bridges. Reflected signals combine with the fundamental to create a ripple pattern. Distant transmission line faults create more ripples in a given frequency sweep than faults closer to the transmission line input. Even at the medium resolution setting, faults can be isolated to 3 millimeters or 0.25% of total distance.

In wireless transmission systems, connector problems are often hard to identify (partial pin-to-pin contact ) and the connections are usually located up a tower. When testing tower mounted equipment, it makes a lot of sense to be able to isolate a problem from the transmission line input at ground level.

### Total Quality Management

TQM processes rely on the use of properly operating components prior to

## High Speed Digital LANs

High speed digital LANs and cable television systems have the same problems as wireless systems. The burgeoning demand for faster data rates (100 Mbs, 145 Mbs ) and added channel capacity (to 1GHz today and higher for HDTV) has pushed the bandwidth requirements to levels that may not be supported by existing, installed coax cabling.

However, that doesn't mean that existing cables can't support the required bandwidth. In many cases a simple connector change will boost the available bandwidth of the transmission line. If cables can be proven to meet SWR and loss specifications, the savings in installation costs will easily pay for any necessary connector replacements. Determining the quality of the existing installed cables requires only two critical tests, transmission loss and SWR (return loss).

Sweep coaxial LAN cables for transmission loss and SWR through at least 3 times the digital data rate. This would be 300 MHz for a 100 Mbs system or 435 MHz for a 145 Mbs ATM transmission line. As a minimum, energy through the square wave's third harmonic must be transmitted to achieve a reliable connection. If the SWR increases rapidly at these higher frequencies, the distance-to-fault software will quickly isolate problem components.

**A technician uses the distance-to-fault mode to isolate the location of a poor (high SWR) connection in a high speed LAN.**

When testing for SWR or return loss on LAN or CATV cables, be sure to use a swept source with very low harmonics. Source harmonics will distort the passband characteristics of any low pass or band pass filter. Most LAN connectors will behave like lowpass filters and reflect the harmonic — causing an erroneously high SWR display. Thus, a source with poor harmonics can display a failure condition when none actually exists. Similarly, test signal separation devices with poor directivity will mask the true performance of the cables. Test component errors can be minimized using a high directivity SWR autotester.

assembly. Since only one set of cables and antennas are usually shipped to a new site, defective antennas or coaxial cables can cause delays which easily exceed the cost of the components themselves.

Scalar measurement systems are used to verify RF components at incoming inspection and after installation. Technicians perform a simple return loss test and document conformance to specification on a DOS disk which is later downloaded into the company database. Afterward, during the site's maintenance phase, the stored data records are available for comparison to the installation team's initial tests.

The 486 microprocessor in the 54100A Series Scalar Measurement Systems easily stores system setups and previous measurement data on a DOS compatible floppy disk. The data is stored and recalled from disk in a standardized ASCII format which is easily transferred to DOS and Windows computer software spread sheets and databases. Most common spread sheet programs are easily configured to automatically produce graphical reports of historical performance or other statistics such as mean and standard deviation (see Figure 6).

Fast access to data in the PC environment is provided by the standardized ASCII format which allows easy integration of statistical process controls for both high throughput component manufacturing processes and remote field service applications. Data acquisition and encapsulation into PC data files is aided using an automated file naming system that will automatically increment the DOS filename by one character every time new data is saved. Thus, data acquisition, presentation, and statistical performance are implemented in a simple, streamlined process.

The 54100A Series Scalar Measurement Systems includes models with frequency ranges to 1.5 GHz, 2.2 GHz, 3.0 GHz, 8.6 GHz, 20 GHz, 32 GHz, and 40 GHz.

For more information, contact Wiltron Company, 490 Jarvis Dr., Morgan Hill, CA 95037; tel: 408-778-2000 or circle Info/Card #242. *RF*

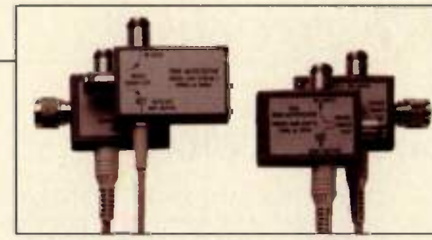


**Figure 5. Precision SWR measurements require high directivity SWR Autotesters and low source harmonics.**

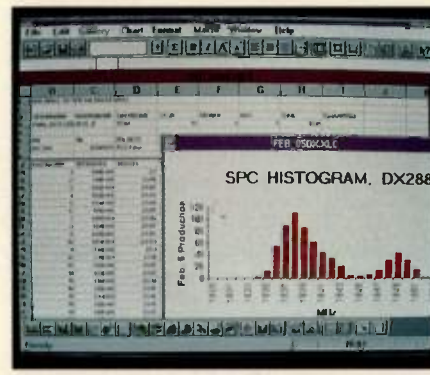
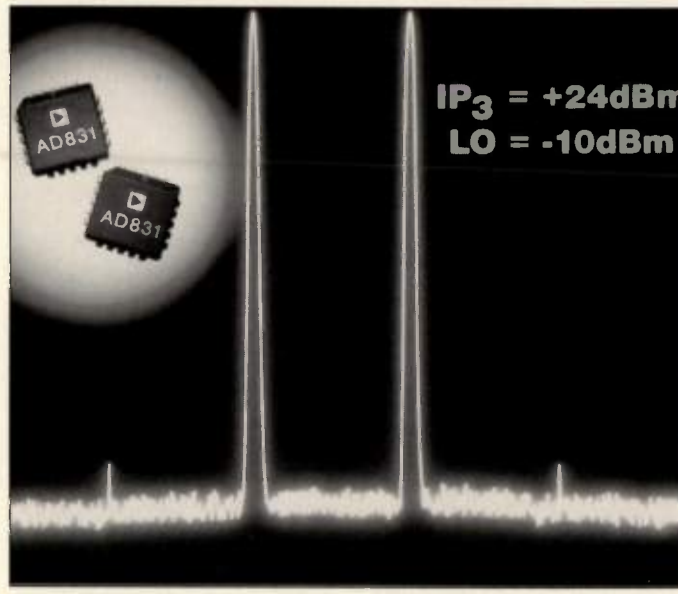



**Figure 6. Test data integrates easily into common spread sheet data bases.**

## 500 MHz Mixer

The AD831 is a versatile RF mixer, which offers low distortion (+24 dBm IP3) for low LO power (–10 dBm) over a 500 MHz bandwidth. The mixer also features better than 70 dB LO-RF at 100 MHz. The AD831 integrates the LO driver and low noise output amplifier together with the mixer core in a single, compact 20-pin PLCC. This allows it to meet or exceed the performance of the best discrete designs in a much smaller footprint. Unlike passive mixers, the AD831 is termination insensitive. The RF, IF and LO ports may be either DC coupled (when the device operates from ±5 V) or AC coupled when operated from +9V. The IF output is available as either a single-ended voltage or a differential current, which can be taken directly from the mixer cell, allowing users to provide their own amplifiers. For voltage output, the AD831 includes a dedicated low-noise amplifier, which can be used to drive filters, 50 ohm loads, and A/D converters, and provides a +10 dBm 1-dB compression point. Although Analog Devices' products have long been used in RF applications, the AD831 marks the first product specifically designed for this market from the newly formed dedicated RF group. The AD831, available in 20-pin PLCC, is priced at $12 in 1000s. Delivery is from stock.

**Analog Devices, Inc.**
**INFO/CARD #240**




## Digitally Tuned Preselector

A digitally tuned broad spectrum RF preselector from Pole/Zero can cover any four bands within 1.5 MHz to 1000 MHz in one small package measuring 6 × 5 × 1.5 inches. The RF preselector may be tuned to 1000 center frequencies within 10 to 200 us across the band and provides 0.5% tuning accuracy from –40 to +85 C. The preselectors have a wide dynamic range and low intermodulation with third order intercept point of +40 dBm. Power handling capability is 1 W inband and 5 W in the stopband. Selectivity is excellent with a 3 dB bandwidth as low as 2% and a 30 dB bandwidth of 18%. Any four MINI-POLE™ and/or MAXI-POLE™ filters in different bands can be selected to cover the appropriate frequencies. The bands available are 1.5-4, 4-10, 10-30, 30-90, 90-200, 200-400, 400-700 and 700-1000 MHz. Prices for standard broad spectrum RF preselectors start at $3280 for small quantities.

**Pole Zero Corp.**
**INFO/CARD #239**

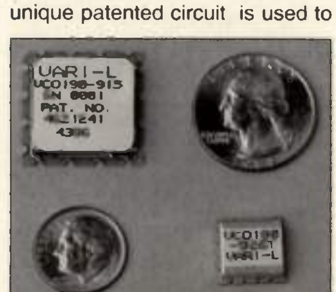
## GPS Filter

Piezo Technology, Inc. (PTI) has introduced an LC filter specifically for the GPS receiver market. Model 8035C is available at 173.9 MHz with a 3 dB bandwidth of 20.5 MHz ±1 MHz, a 40 dB bandwidth of ±60 MHz, and a 50 dB bandwidth of ±90 MHz to 375 MHz. The filter response type is Chebychev. Other features include a 1.5:1 VSWR, 10 ns maximum differential group delay, 32 ±2 ns absolute delay at $f_0$, and 3.0 dB maximum insertion loss. Source and load impedance are 50 ohms. The unit operates over the temperature range of –55° to 110° C. The model 8035C is housed in a hermetically sealed, 0.70 × 0.40 × 0.17 inch (L × W × H) surface mount package. Pricing is less than $175 in small quantities, and less than $100 for quantities greater than 100.

**Piezo Technology, Inc.**
**INFO/CARD #238**

## VCOs for Wireless Designs

The VCO 190 series of low cost VCOs produce 0 dBm output power over the wireless communications bands from 45 to 3000 MHz. All models are application specific designed for exceptionally low phase noise (–118 dBc/Hz at 10 kHz offset at 490 MHz) with tuning bands from 3% to 30% of center frequency. The miniature surface mount unit operate from 5 VDC with usage down to 3 V allowed from –35° to +85° C. A unique patented circuit is used to achieve full specified performance into 4:1 VSWR loads with less than 10 mA of typical current gain. Models with separate low modulation sensitivity ports are also offered for direct FM transmitter or high speed dual loop applications. These devices are robotically assembled in an ISO 9000 approved facility, and automatically tested to produce uniformity consistent with volume production applications.




**Vari-L Company, Inc.**
**INFO/CARD #237**

## Rb Timebase Counter

Stanford Research Systems announces the commercial release of the SR625 frequency counter, designed for making traceable frequency calibrations of base stations, transmitters and many types of communication systems. The SR625 combines the high resolution of the SR620 counter with the atomic accuracy of a rubidium timebase to measure frequency drift and stability with extremely high accuracy. The counter directly measures signals up to 2.2 GHz with twelve digits of resolution in a one second measurement interval. The Rb timebase has an accuracy of $5\times10^{-11}$ and a monthly drift of $5\times10^{-11}$ to ensure accurate and traceable measurements over time. The SR625 has a ten minute warmup time, is compact, and also has a 10 MHz Rb output to drive other test equipment such as spectrum analyzers or synthesizers. The unit measures 14 × 17 × 3.5 inches and weighs 16 pounds. U.S. list price is $14,850 with delivery four weeks ARO.

**Stanford Research Systems**
**INFO/CARD #236**

## CABLES & CONNECTORS

### Mini-UHF to SMA Adapter

The RFU-642 between-series connector adapts a mini-UHF female and a (Motorola) SMA style female connector. The connector body is produced entirely of nickel-plated machined brass with machined teflon dielectric and gold plated female contacts.
**RF Industries, Ltd.**
**INFO/CARD #235**

### Jumper Cables

VALUFLEX™ cable assemblies are manufactured using genuine HELIAX® coaxial cable and are designed for indoor use up to 3 GHz. The jumper cable assemblies are available in 1/4 inch FSJ1-50A HELIAX for general connectivity, 3/8 inch FSJ2-50A for more demanding applications, and 1/4 inch ETS1-50T for high power and plenum applications. The cables are stocked in the most popular sizes and with N, UHF, and BNC connectors.
**Andrew Corp.**
**INFO/CARD #234**

### Flexible Jumpers

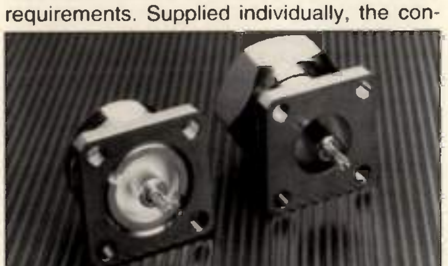
The jumper cable developed by the coaxial cable department of Huber+Suhner AG can undergo 15,000 bending cycles with a radius of 110 mm and an angle of ±90 degrees without affecting transmission characteristics. Connectors have been specially designed to accompany these cables and are available in the most widely used styles.
**Huber+Suhner AG**
**INFO/CARD #233**

### Flexible, 100% Shielded Cables

Re-Flex™ cables from Insulated wire utilize a unique alloy laminate underneath a copper braid, offering the shielding equivalent while remaining easily formable by hand. These cables are reformable with no electrical or mechanical degradation.
**Insulated Wire, Inc.**
**INFO/CARD #232**

### 7/16 Connectors

A line of quick-change RF 7/16 DIN connectors designed to fit all popular models of multilevel; wattmeters from Tru-Connector meet DIN 47223 and IEC 169.4 interface requirements. Supplied individually, the connectors provide 50 ohm impedance, low VSWR up to 7.0 GHz, and have a voltage rating of 2700 Vrms. Cable assemblies can also be provided.
**Tru-Connector Corp.**
**INFO/CARD #231**



## SIGNAL SOURCES

### TCXOs for GPS

Tele Quarz offers low phase noise TCXOs is standard frequencies of 32 MHz a 8 MHz for use in GPS receivers. The oscillators feature a 20 × 20 mm enclosure, an internal temperature sensor, and analog and two cophasal outputs. The units are vibration insensitive. Other frequencies are available.
**Tele Quarz GmbH**
**INFO/CARD #230**

### OCXO

the 252-1130 ovenized crystal oscillator (OCXO) by MTI offers 5 MHz output with thermal stability of $1\times10^{-9}$ ($\pm5\times10^{-10}$) over a temperature range of –30 to +70° C. Aging is better than $5\times10^{-11}$/day and $1\times10^{-8}$/year. Phase noise is specified at –110 dBc/Hz at 1 Hz offset, –145 dBc/Hz at 100 Hz, and –160 dBc/Hz at 10 kHz. HCMOS or +7 dBm sinewave output is available. Dimensions are 60 × 67 × 27 mm. Other industry-standard packages are available. Prices for the 252-1130 start at $640.
**Milliren Technologies, Inc.**
**INFO/CARD #229**

## TEST EQUIPMENT

### Quartz Frequency Standard

Starting at $995, the model 2950A quartz frequency standard has simultaneous sinewave outputs of 5 MHz, 1 MHz and 100 kHz. The 2950A-01 has less than $1\times10^{-9}$ daily aging and costs $995; the 2950A-02 has $<1\times10^{-10}$ daily aging and costs $1395; the 2950A-03 has $<5\times10^{-11}$ daily aging and costs $1995. Harmonic outputs are down <–40 dBc, phase noise is –152 dBc/Hz at 100 Hz offset for the 2950A-03, and a voltage-controlled fine frequency adjustment allows locking to a primary standard.
**Novatech Instruments, Inc.**
**INFO/CARD #228**

### RF Emulator

The TAS 4500 can be configured to emulate two independent RF channels, each with three paths. Delay, path loss, Rayleigh fading, Rician fading, and log-normal fading characteristics can be programmed for each path. The two channels can be combined to form a single six-path channel. The unit has a built-in frequency synthesizer, and is GPIB and RS-232 controllable.
**Telecom Analysis Systems, Inc.**
**INFO/CARD #227**

# Product Spotlight: Amplifiers

## Low Voltage MMIC Amps

Low voltage power amplifiers have been added to Mitsubishi's line of ultra-small GaAs MMICs for PCN applications. The

devices operate in the 1.89 to 1.95 GHz band. The MMICs measure 8.4 × 12.2 × 1.7 mm and feature minimum power output of 26 dBm. The MGF7132 operates on a 4.7 V supply, and the MGF7133 operates on 3.3 V. Unit price for both is $45.00 in quantities of 25.

**Mitsubishi Electronics America, Inc.**
**INFO/CARD #226**

## Low Noise Amplifier

The VMA0518D-120 ultra-low-noise amplifier instantaneously spans 0.5 to 18 GHz, featuring 2.8 dB maximum noise figure and 20 dB gain coupled with ±0.8 dB ripple and ±10 dBm output power. Housed in a 1.0 × 1.0 × 0.22 inch package with removable SMA-F connectors, the unit operates from +15 VDC at 140 mA. Other amplifiers in this family are available with gains to 46 dB and output powers to +19 dBm.

**Veritech Microwave, Inc.**
**INFO/CARD #225**

## CATV Amplifiers

Three new devices extend Motorola's portfolio of trunk and line extender amplifiers to 1 GHz. The MHW7182 covers 40 to 750 MHz with 110 channels, 18.8 dB gain and 5.5 dB typical noise figure. The MHW8182 covers 40 to 860 MHz with 128 channels, 19.0 dB gain and 6.0 dB typical noise figure. The MHW9182 covers 40 to 1000 MHz with 152 channels, 19.2 dB gain and 6.5 dB typical noise figure. The MHW7182, MHW8182 and MHW9182 cost $47.19, $54.54 and $65.84, respectively.

**Motorola Semiconductor**
**INFO/CARD #224**

## High-Mu Power Triode

The Svetlana 3CX3000A7 is a high performance ceramic/ metal power triode designed for use in zero-bias, class AB, or class B RF or audio amplifiers. A modern mesh filament is used, replacing the old-fashioned hairpin construction. The low-inductance, mesh-filament basket also forms a natural extension of the cylindrical stem geometry into the active area, giving superior VHF performance.

**Svetlana Electron Devices**
**INFO/CARD #223**

## 50 W, UHF Amplifier

ENI's model 550L power amplifier produces 50 W of class A output power over a 1.5 to 400 MHz frequency range. With a gain of 50 dB, the 550L features low harmonic and intermodulation distortion; all harmonics are more than 23 dB below the main signal at full power. The amplifier is unconditionally stable, has +13 dBm overdrive protection, and infinite maximum load VSWR. The 550L is available for 30-day delivery at a cost of $7965.

**ENI**
**INFO/CARD #222**

## Cellular Hybrid Amp

Model PA1032 from Phoenix Microwave offers ultra linear output power of +27 dBm, over the 800 to 900 MHz range with a typical third order intercept of 44 dB. Using proprietary design techniques, this amplifier has1 dB maximum noise figure across the entire operating frequency. The unit is offered in 24-pin DIP and surface mount packages.

**Phoenix Microwave Corp.**
**INFO/CARD #221**

## Pulse Counters

A family of broadband pulsed frequency counters, consisting of models 585C and 588C, has built-in delaying pulse generators and full pulse parameter measurements. The 585C covers 100 Hz to 20 GHz, while the 588C covers 100 Hz to 26.5 GHz, with optional coverage to 170 GHz. Both instruments measure CW or pulsed signals to 1 Hz resolution and provide 200 W burnout protection.

**EIP Microwave, Inc.**
**INFO/CARD #220**

## Arbitrary Waveform Generator

Model 2650 is a 50 MS/s programmable arbitrary waveform generator. The unit provides 12-bit vertical resolution and 64k points per channel, with an expansion option to 256k. The 2650 is fully supported by National Instruments' LabWindows® and RapidSystems' R4 drivers The model 2650 is priced at $3995 as a single channel generator, $5990 for dual channels. Additional memory is $495 per channel.

**Analogic Corp.**
**INFO/CARD #219**

## PC-Based TDR

The time domain reflectometer (TDR) head from Hyperlabs has 35 ps risetime capability. The HL-1100 remotely connects to a National

Instruments SCXI mainframe, isolating the TDR circuitry from the noise generated by the PC, and allowing connection to inconveniently located test connectors. The HL-1100 TDR head is priced at $4995.

**Hyperlabs, Inc.**
**INFO/CARD #218**

# SIGNAL PROCESSING COMPONENTS

## High Power Splitter

A high power, two-port splitter/combiner pair for the 88 to 108 FM broadcast band uses Wilkinson principle. Microstrip design makes these units compact, and a caseless design makes them inexpensive. Standoffs for mounting are standard, as are BNC connectors. The power handling capability is 600 + W. Price is $74.99 per pair in quantities of 1 to 9 units.

**RF Power Systems**
**INFO/CARD #217**

## Miniature Mixers

The RMS-11X mixer is a surface mounted, all-ceramic package measuring only 0.25 x 0.31 × 0.2 inches and costing $3.95 each in quantities between 10 and 49. This mixer operates in the 5 to 1900 MHz range and has 1 dB compression at 1 dBm RF input. Conversion loss is 6 dB. All specs are statistically controlled to within 4.5σ fromthe mean.

**Mini-Circuits**
**INFO/CARD #216**

## Low-Loss Mixer

Merrimac's DMG-2D series of mixers is designed for wideband applications from 2.5 to 6.5 GHz, or narrower bands within that range requiring more exacting specifications. The IF frequency range extends from DC to 2000 MHz, with a typical midband SSB conversion loss of 4.5 dB. The surface mount package measures 0.45 inches square and nominally weighs 0.1 oz.

**Merrimac Industries, Inc.**
**INFO/CARD #215**

ZRON

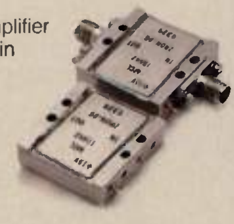
# 2-8GHz AMPLIFIERS


## Up to 100mW, 20dB Gain, 2-8GHz, only $495^{00}$

Mini-Circuits fused the science of economy and technology together to create the very broad band, 2 - 8GHz ZRON-8G amplifier. Each SMA connector on this amplifier can be easily removed for quick conversion to drop-in assembly capabilities . . . and with a price tag of just $495, the ZRON-8G will fit as well into your budget as it will your project. But, don't let the small price fool you. Each hermetically sealed unit is built extremely tough. Even if the power supply voltage is shorted under full RF power, the ZRON-8G amplifier will survive without damage.

Suitable for both lab and systems applications, this multi-functional GaAs amplifier delivers 20dBm minimum power output at 1dB compression and has a linear gain of at least 20dB over the full frequency range. To that, add a VSWR of 2.0:1 maximum over the whole band and you have a unit that's unconditionally stable for all load and source impedance magnitude and phase.

So, call your Mini-Circuits distribution center for guaranteed one week shipment and seize the competitive power packed in the new ZRON-8G amplifier!



**Available with or without heat sink**

SPECIFICATIONS Model: ZRON-8G

| | |
|---|---|
| Freq. Range GHz | 2-8 |
| Gain (dB) Min. | 20 |
| Power (dBm) | |
| Min. Output (at 1dB Comp.) | +20 |
| Dynamic Range | |
| NF(dB) Typ. | 6 |
| Intercept Point (dBm) 3rd Order Typ. | 30 |
| VSWR In/Out | 2.0:1 |
| DC Power | |
| Voltage | +15 |
| Current mA Max. | 310 |

INFO/CARD 34

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# *RF products*

## Reed Relays

Kilovac's "S" series of high power reed relays are PC board mountable. DC performance ratings range from 300 V, 2 amp relays to 10,000 V, 5 amp relays. The series can handle RF power handling duties. Prices start as low as $20.50 each for 1 to 9 pieces.
**Kilovac Corp.**
**INFO/CARD #214**

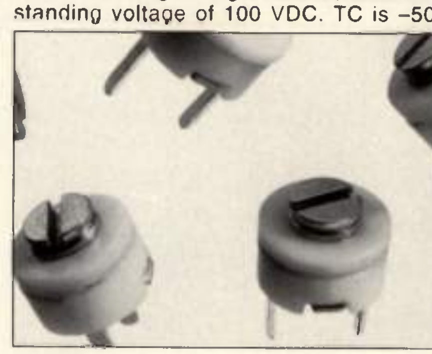
## Isolators/Circulators

KW Microwave has introduced a line of commercial isolators/circulators to its line of ferrite products. An example is the cellular band, 890 to 935 MHz isolator with detector. The unit has 0.3 dB typical insertion loss, 23 db isolation minimum, and VSWR of 1.15:1 maximum.
**KW Microwave Corp.**
**INFO/CARD #213**

## DISCRETE COMPONENTS

## Trim Caps

The RS series of ceramic trimmer capacitors from Voltronics is 0.2 inches in diameter, with two axial leads on 0.15 inch centers. Three capacitance ranges are available: 0.6 to 3.0 pF, 1.0 to 5 pF, and 2 to 10 pF. The series' working voltage is 50 V, with withstanding voltage of 100 VDC. TC is –500



±1000 ppm/°C. Q is over 250 at 1 MHz. Prices are $0.46 each in 10,000 piece quantities. Delivery is from stock for orders up to 5000.
**Voltronics International Corp.**
**INFO/CARD #212**

## SMT Crystals

The H-180 series quartz crystals are only 1.8 mm high and are packaged in resin-sealed ceramic packages. The crystals are available in four accuracies: ±10, ±30, ±50, ±100 ppm at 25° C, and in four temperature sensitivities: ±10, ±30, ±50, ±100 ppm over –10 to +60° C. Fundamental frequencies are available from 10 to 40 MHz; 3rd overtones to 90 MHz. In 10,000 unit quantities, the H-180 series crystals are priced from $0.90 to $3.00 each, depending on performance.
**Raltron Electronics Corp.**
**INFO/CARD #211**

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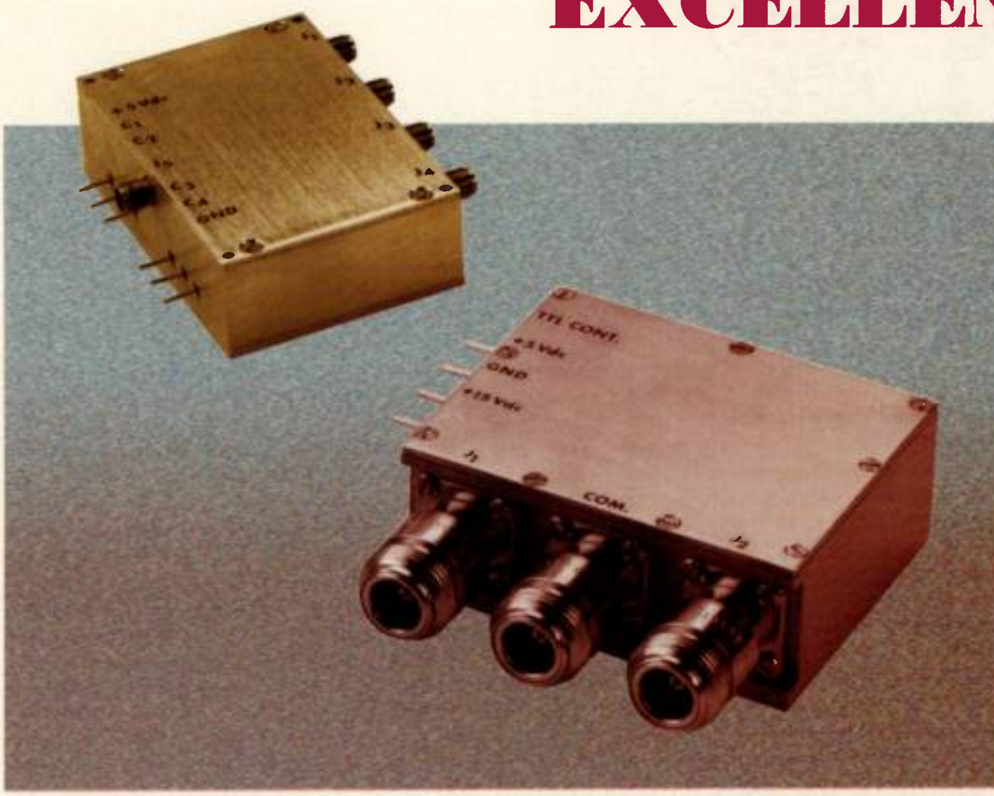
# PERFORMANCE

# Reliability

# EXCELLENCE




***50S-092*** SMA • 1P4T • Solid State Switch
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***50S-788*** N • 1P2T • Solid State Switch
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INFO/CARD 37

# A First Introduction to Direct Sequence Spread-Spectrum

By Gary A. Breed
Editor

*Spread Spectrum (SS) communications is growing in popularity, especially in the unlicensed frequency bands allocated for Industrial, Scientific and Medical (ISM) applications. With its roots in military secure and anti-jamming transmission techniques, SS has been thoroughly analyzed and developed, and much of the reference material is based on such high-performance applications. This tutorial reviews the basic concepts of one type of SS, direct sequence.*

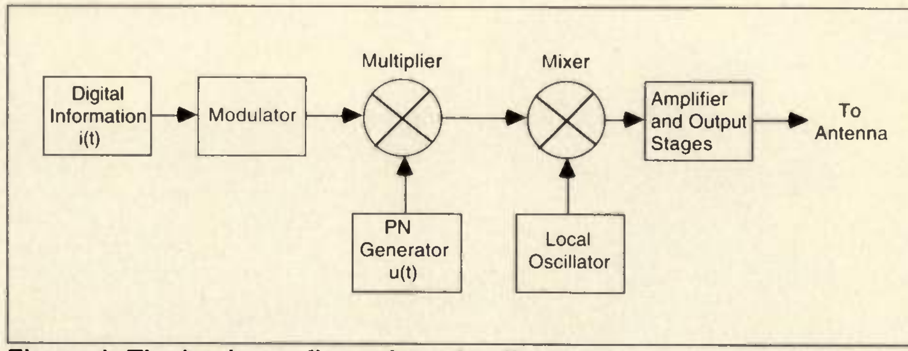


**Figure 1. The basic configuration of a direct sequence spread spectrum generator/transmitter.**

Direct sequence spread spectrum can be characterized as a single carrier, with modulation applied that creates an RF signal with a bandwidth that is much wider than the bandwidth of the information it is carrying. This characteristic is what gives SS its name — the signal is spread across a part of the spectrum.

The modulation applied is designed to create an RF signal with properties much like random noise. The resulting signal looks like noise, yet it is deterministic since the modulation is mathematically generated using a pseudo-noise (PN) code.

The noise-like properties make the signal difficult to detect and demodulate, yet its deterministic nature makes it possible for a receiver to "unspread" the signal using the same PN code.

The above combination of properties demonstrate the attractiveness of direct sequence SS:

- It is difficult to demodulate without knowing the PN code.
- Multiple channels with different PN codes can occupy the same band.
- It causes low interference, since the energy is spread over a wide bandwidth.
- It has low susceptibility to interference because modulation and demodulation are synchronous, not responding to other signals.

The most significant disadvantage to direct sequence SS is that it requires a total energy that is above the level of noise and other signals within the same bandwidth. It is neither a "below the noise" system, nor is it as robust in the presence of interference as some people believe [1]. However, it offers high-reliability transmission with relatively small signal-to-noise ratios, a big advantage over narrowband modulation.

## Generating Direct Sequence SS

There are four contributors to the final SS signal, as shown in Figure 1 — the digital data stream being transmitted, i(t); the PN code in the form of "chips," u(t), with a phase that varies rapidly compared to the data rate; the modulation type, which may be any type of phase modulation, but is typically QPSK; and the operating frequency, usually involving one or more upconversion stages.

The high rate of phase change created by the chipping sequence results in a very wide bandwidth. The signal contains several chips per bit of data, which a correlated receiver will see as redundant information, but which an uncorrelated receiver will see as a rapid series of bits that approximate noise. The number of chips per bit of input data typically is in the range of hundreds to a few thousand.

The PN code may also be applied directly to the digital data stream, rather than multiplying the modulated baseband signal. In this case, the PN sequence is considered to be a voltage waveform which multiplies the data stream by either +1 or –1. If the data stream is considered to be return-to-zero (the digital states are 1 and 0), then the resulting encoded waveform has three-states, –1, 0, and +1. If the data stream is considered to be non-return-to-zero (the digital states are +1 and –1), the resulting encoded waveform will have two states, +1 and –1.

A more complex method generating a direct sequence SS signal takes advantage of the quadrature signals necessary for QPSK. In this method (Figure 2), the in-phase (I) and quadrature (Q) paths are each phase modulated with different chipping sequences, $u_1(t)$ and $u_2(t)$. The resulting complex, wideband signal is more difficult to intercept, since it requires two PN codes.

There is not sufficient opportunity to analyze these methods in detail in this short tutorial. They are presented to make the reader aware of the configurations he or she may find when pursuing further research on this subject.

## Receiving Direct Sequence SS

A spread spectrum receiver is essentially the reverse of the generator/transmitter. However, a few additional circuit elements are often added to compen-

sate for the "real world" that accompanies the signal in its transmission path.

For example, the usual bandpass filter will be needed to eliminate signals outside the desired frequency range. Automatic gain control (AGC) and frequency synthesis are other typical receiver functions that apply to all receivers, including those intended for SS.

A specific problem for SS is that the receiver will not be automatically synchronized with the transmitted signal. Even if both are phase-locked to a single stable reference, such as WWVB or the Global Positioning System (GPS), propagation will introduce both long- and short-term delays which appear as phase shifts.

Receiver tracking of the spreading PN code can be done in two ways. The first is a simple search mode, where the receiver phase is shifted until the system is synchronized with the incoming signal. This trial-and-error approach is not the most reliable way to achieve synchronization unless the signal path is such that it introduces a minimum of error. For short-range systems, it may be appropriate.

The other major way to maintain synchronization is the use of "early" and "late" codes, de-spreading PN codes that are phase shifted to lead and lag the signal to be received [2]. An error signal can be generated that is proportional to the magnitude of the phase error of each code, identifying where the proper phase should be. This error signal can control the phase shift of the primary de-spreading code through a closed-loop system to maintain lock.

The early and late codes do not have to be separate signals. One code can be alternately shifted high and low in phase (dithered), with the error signal sampled in each state. This can simplify the error-tracking circuitry considerably.

The availability of low cost digital signal processing (DSP) components and DSP development tools has simplified the process of tracking and de-spreading the received signal. Review the references for additional information on the mathematical relationships that govern the design of spreading and de-spreading (convolving) circuitry.

The other feature that a direct sequence SS receiver may include is rejection of CW interfering signals. As stated earlier, direct sequence SS requires a positive signal-to-noise ratio, albeit a small one. A strong CW signal within the bandwidth of the SS signal can block transmission.

To restore communications in this situation, narrowband filtering may be implemented [3] to reject the interfering signal, or reduce it to a low enough amplitude that the SS system is again functional. Technology is readily available for tunable IF notch filters using crystals at IFs typically below 70 MHz, or SAW filters above 45 MHz. In the event of a failure, the receiver can either detect the interfering signal, or simply sweep the passband with the notch to see if the SS signal can be restored.

## General Considerations

Data rates in the several megabits per second range can be supported in a direct sequence SS system. Combined with the inherent security of PN codes (along with other encryption tech-

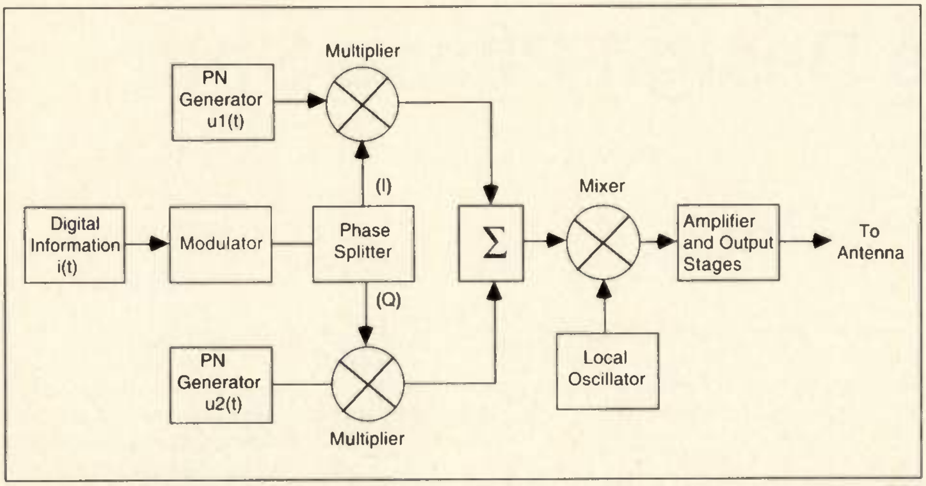


**Figure 2. QPSK direct sequence SS generation using separate PN codes in the I and Q paths.**

niques), this makes direct sequence SS an attractive choice for wireless local area networks in critical applications such as banking.

The ability to use well-established QPSK modulation methods and highly-integrated DSP devices combine to make equipment design relatively straightforward and inexpensive.

Finally, the simple fact that SS is a reliable means of radio transmission explains its popularity among designers of new wireless data communications equipment. *RF*

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# NPOLE Helps Design Phase-Shift Networks

By R. Dehoney
Consultant

*This article gives the theory for the design of one, two, three and four pole RC active and passive allpass networks. With suitable choice of pole frequencies, these networks can be used to form wideband constant phase difference circuits. The programs discussed in this article continue the work started in reference 1. They calculate the element values for some active and passive RC one-, two-, three-, and four-pole allpass networks, given pole frequencies, which may be calculated using the program described in [1] or some other program. The work is based on the work of Albersheim and Shirley [2] and Toffer [3].*

The passive and active versions of the circuit are shown in Figures 1 and 2. For either circuit,

$$\frac{V_o}{V_i} = \frac{(Z_2 - Z_1)}{(Z_2 + Z_1)} \quad (1)$$

For the circuit to be allpass, $|V_o/V_i|$ must be constant, therefore,

$$\frac{V_o}{V_i} = G\frac{f_1(p)}{f_2(p)} \quad (2)$$

where

$$f_1(p) = (p_1 - p)(p_2 - p)(p_3 - p)\cdots \quad (3a)$$

$$f_2(p) = (p_1 + p)(p_2 + p)(p_3 + p)\cdots \quad (3b)$$

$$p = j2\pi f \quad (3c)$$

and the constant output is $|V_o| = G \cdot V_i$.

Single pole circuits are simple enough to analyze directly. Figure 3 shows a one-pole circuit which has resistors on the input and output. This makes it useful in the real world where finite source and load resistance is inevitable.

For this circuit,

$$\frac{V_o}{V_i} = A\frac{(p - \omega_1)}{(p + \omega_2)} \quad (4)$$

where:

$$A = \frac{(R2 - R1)}{\left(R1\left(1 + \frac{R2}{RL}\right) + R2\right)} \quad (5a)$$

$$\omega_1 = \left((R2 - R1)C1\right)^{-1} \quad (5b)$$

$$\omega_2 = \frac{\left(1 + \frac{R2}{RL}\right)}{C1\left(R1\left(1 + \frac{R2}{RL}\right) + R2\right)} \quad (5c)$$

To be allpass, $\omega_1 = \omega_2 = p_1$, the pole frequency. Given $p_1$ and choosing the values of C1 and RL, the equations can be solved.

The first of the programs to be described here, 1POLE, does the drudgery. You are asked to enter the pole frequency and C1 after which a list of gain vs. RL is printed out. When you choose RL, R1 and R2 are calculated and all of the values are displayed, along with $V_{out}/V_{in}$. You then have the option of choosing new values or a new pole frequency.

Multipole circuits are too complicated for this approach to be practical. Instead, $Z_1/Z_2$ (or $Y_2/Y_1$) is expressed in terms of both circuit elements and pole frequencies. Knowing the pole frequencies, a comparison gives the circuit values.

## Two-Pole Circuits

Program operation can best be understood by considering the two-pole circuit. For this circuit to be allpass,

$$f_1(p) = (p_1 - p)\cdot(p_2 - p) \quad (6a)$$

$$f_2(p) = (p_1 + p)\cdot(p_2 + p) \quad (6b)$$

From (1),

$$\frac{Z_1}{Z_2} = \frac{1 - \frac{V_o}{V_i}}{1 + \frac{V_o}{V_i}} = k\frac{g_1(p)}{g_2(p)} \quad (7)$$

where

$$g_1(p) = p^2 + b_1\frac{p}{k} + b_0 \quad (8a)$$

$$g_2(p) = p^2 + b_1 \cdot p \cdot k + b_0 \quad (8b)$$

$$k = \frac{(1+G)}{(1-G)} \quad (8c)$$

$$b_1 = p_1 + p_2 \quad (8d)$$

$$b_0 = p_1 \cdot p_2 \quad (8e)$$

For $Z_1$ and $Z_2$ to have realizable values, $g_1(p)$ and $g_2(p)$ must have real roots. If we choose k to make the two of roots of $g_1(p)$ merge, then the roots will be real and the circuit will have the least

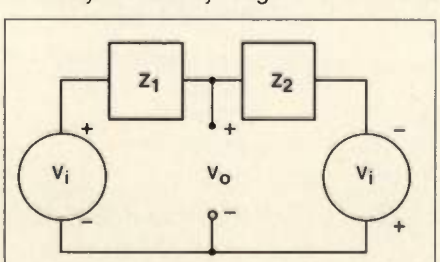


**Figure 1. Passive allpass network.**

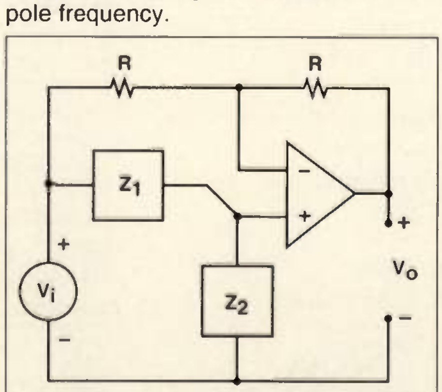


**Figure 2. Active allpass network.**

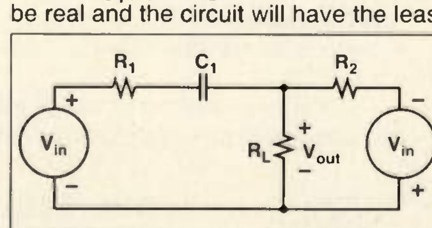


**Figure 3. Single pole circuit.**

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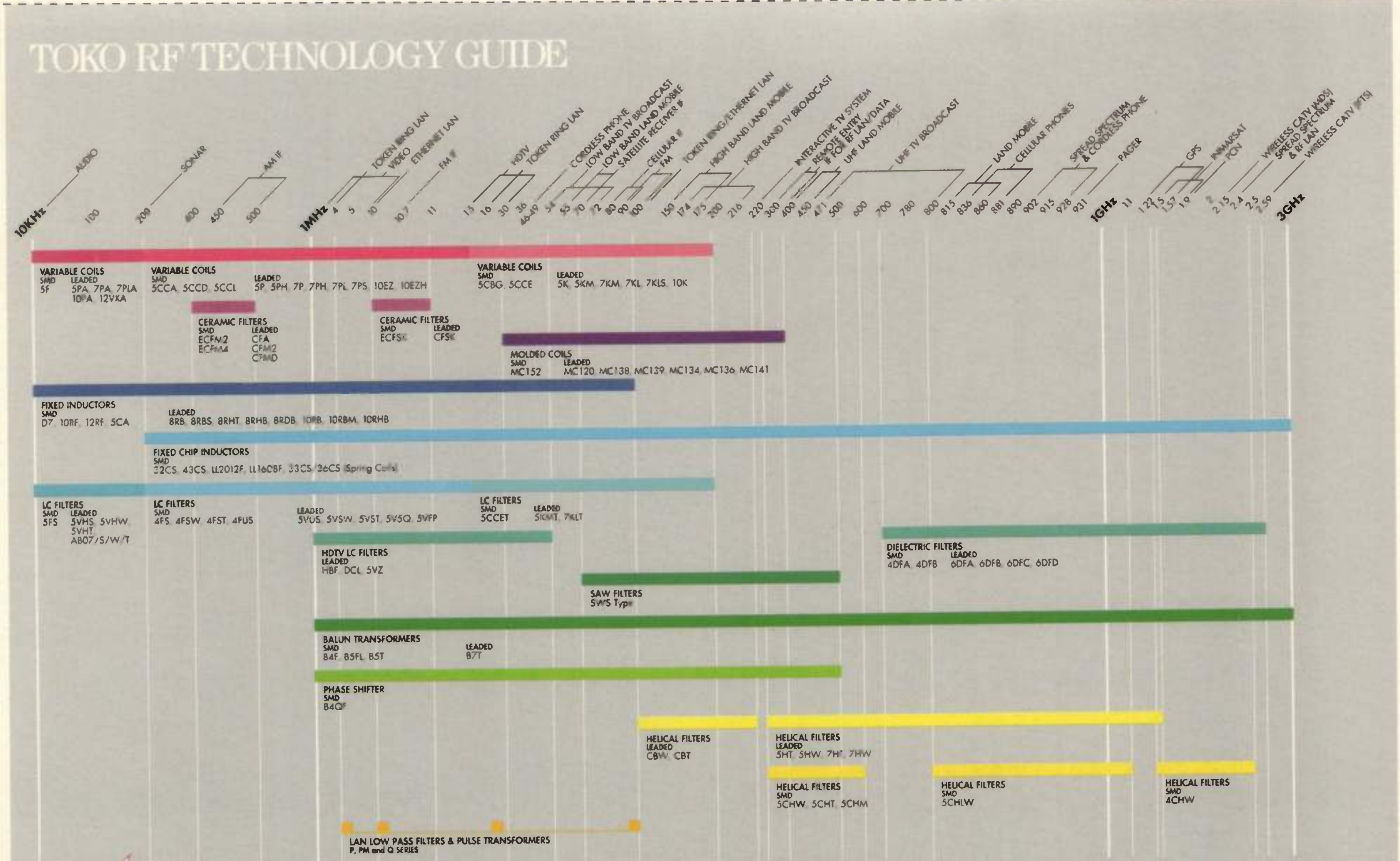


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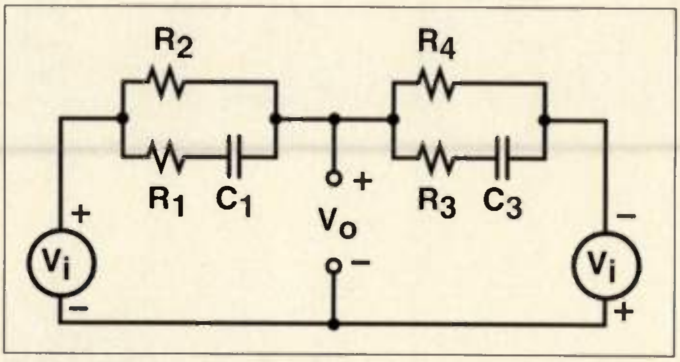


**Figure 4. Two-pole circuit.**

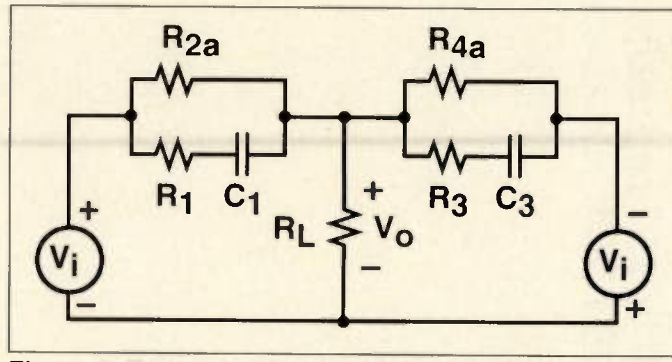


**Figure 5. Two-pole circuit with load resistor.**

loss. Letting $k_c$ represent that value of k, the resulting expression is:

$$\frac{Z_1}{Z_2} = \frac{k_c(p+p_a)^2}{(p+p_aM)(p+p_aN)} \quad (9)$$

where the double root,

$$p_a = \sqrt{b_0} \quad (10a)$$

$p_a \cdot M$ and $p_a \cdot N$ are the two denominator roots and,

$$k_c = \frac{b_1}{2p_a} \quad (10b)$$

$$M = 2k_c^2 + \sqrt{4k_c - 4} \quad (10c)$$

$$N = 2k_c^2 - \sqrt{4k_c - 4} \quad (10d)$$

A two-pole circuit is shown in Figure 4.

For this circuit:

$$\frac{Z_1}{Z_2} = \frac{R2}{R4} \cdot \frac{a}{b} \frac{(p+\omega_1)\left(p+\frac{\omega_2}{a}\right)}{(p+\omega_2)\left(p+\frac{\omega_1}{b}\right)} \quad (11)$$

where

$$\omega_1 = \frac{1}{R1C1},\ \omega_2 = \frac{1}{R2 \cdot C2} \quad (10a,b)$$

$$a = \frac{R4}{R2}+1,\ b = \frac{R3}{R1}+1 \quad (11a,b)$$

By comparing the two Z1/Z2 equations, the circuit values can be obtained.

Choose R1, then

$$R3 = \frac{R1}{k_c} \quad (12a)$$

$$R2 = \frac{R1}{\left(\frac{2}{N}-1\right)} \quad (12b)$$

$$R4 = \frac{R2}{k_c} \quad (12c)$$

$$C1 = \frac{1}{p_aR1} \quad (12d)$$

$$C3 = \frac{1}{p_aM \cdot R3} \quad (12e)$$

A useful modification to the circuit of Figure 4 is to include a load resistance, $R_L$. The resulting circuit is shown in Figure 5.

The new circuit values are:

$$\frac{1}{R2a} = \frac{1}{R2} - \frac{1}{2 \cdot RL} \quad (13a)$$

and

$$\frac{1}{R4a} = \frac{1}{R4} - \frac{1}{2 \cdot RL} \quad (13b)$$

Equivalent forms of $Z_1$ and $Z_2$ are shown in Fig. 6.

For the $Z_1$ network, the conversion equations are:

$$RA = \frac{R1 \cdot R2}{(R1+R2)} \quad (14a)$$

$$RB = (R2-RA) \quad (14b)$$

$$CB = \frac{C1(R2+R1)}{RB} \quad (14c)$$

and similarly for the $Z_2$ network.

By taking advantage of this conversion it is possible to design a circuit that accommodates both a source and a load resistance. Such a circuit is shown in Figure 7.

2POLE solves for the element values of this circuit. The program asks for the two pole frequencies and the desired load resistance. It then finds the value of CB which makes RB infinite. With that value or any larger value entered, the program determines the other circuit values. A new value of CB can be entered if the values are not suitable.

The active version of the circuit is shown in Figure 8. It differs from the circuit of Figure 2 by including $R_x$ and $R_y$. This allows the gain to be set by the designer.

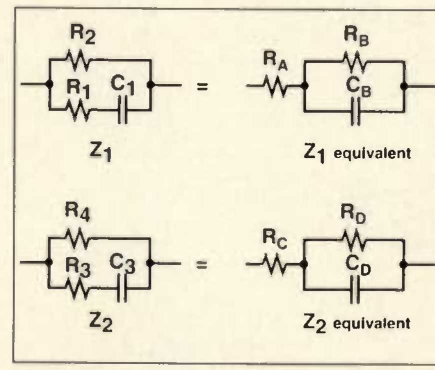


**Figure 6. Equivalent impedances with and without a series resistance.**

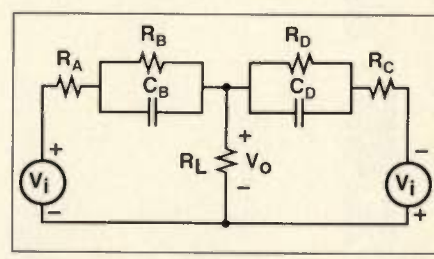


**Figure 7. Two-pole allpass network with source and load resistances.**

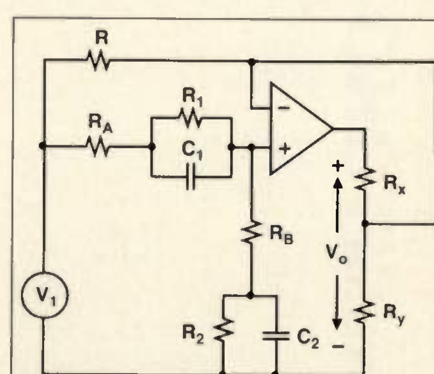


**Figure 8. Active allpass network with source and load resistances.**

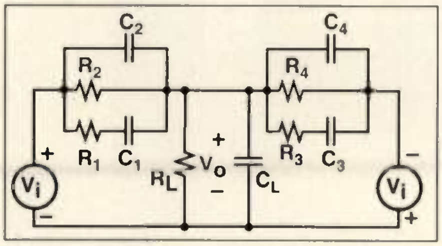


**Figure 9. Three-pole network.**

## 3- and 4-Pole Circuits

The design of three- and four-pole circuits follows the same steps as outlined above: The equations for $Z_1/Z_2$ are developed from $V_o/V_i$. The value of k giving confluent roots is found and the equations expressed in terms of those roots. The equation for $Z_1/Z_2$ is found in terms of circuit elements, and the two equations are compared to obtain the element relations.

3POLE and 4POLE automate this procedure. Given the pole frequencies and an element value, the programs calculate and display the other element values. If the values are not suitable, new values can be obtained. Active and passive three- and four-pole circuits can be chosen.

Figure 9 shows the passive circuit used in 3POLE.

The RC load is optional. If it is included, the element values are changed as follows:

$$\frac{1}{R2a} = \frac{1}{R2} - \frac{1}{2 \cdot RL} \quad (15a)$$

$$\frac{1}{R4a} = \frac{1}{R4} - \frac{1}{2 \cdot RL} \quad (15b)$$

$$C2a = C2 - \frac{CL}{2} \quad (15c)$$

$$C4a = C4 - \frac{CL}{2} \quad (15d)$$

An alternate three-pole network is included in 3POLE. This network includes resistors on input and output. The circuit is shown in Figure 10.

4POLE analyzes one active and two passive circuits. The basic four-pole circuit is shown in Figure 11.

It can be modified to include a resistive load by changing values as shown below:

$$\frac{1}{R3a} = \frac{1}{R3} - \frac{1}{2 \cdot RL} \quad (16a)$$

$$\frac{1}{R6a} = \frac{1}{R4} - \frac{1}{2 \cdot RL} \quad (16b)$$

A version with input and output resistors is included in the program. The circuit is shown in Figure 12.

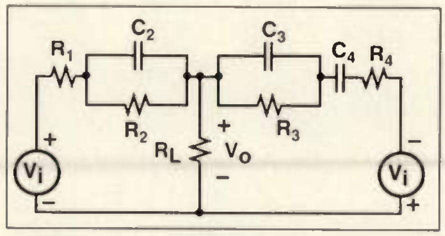


**Figure 10. Three-pole network using resistors on the input and output.**

The program asks for the four-pole frequencies and a value for RS. It then calculates a minimum RL and asks for an RL input. It then calculates and displays all element values.

## Push-Pull Sources

The passive circuits can be implemented in various ways. All that is required is a push-pull source. Figure 13 shows one convenient way using the so-called long-tailed pair.

Choose a network having source resistors and modify the calculated values to account for the resistance looking back into the FET circuit.

Other techniques include the use of a 180 degree hybrid, unity gain inverter, or one of the new transconductance amplifiers with differential output such as the Maxim MAX435.

## Conclusion

It is my hope that these circuits will usefully augment the circuits presented in Reference 1, (which presented the constant phase difference network design program PHASEDIF), and that this work will encourage others to analyze and describe other allpass circuits.

The programs are all unsophisticated BASIC programs and should run on any PC. Please call or write me if you come across errors or if you have questions.

*The program,* NPOLE, *is available through the RF Design Software Service. For ordering information, see page 64.* **RF**

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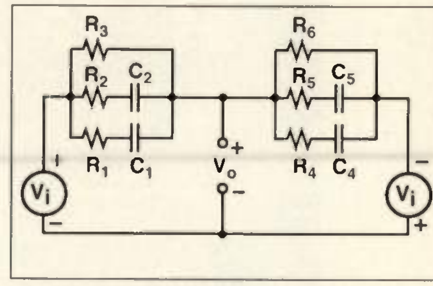


**Figure 11. Four-pole network.**

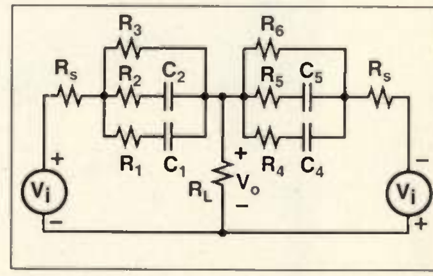


**Figure 12. Four-pole network with input and output resistors.**

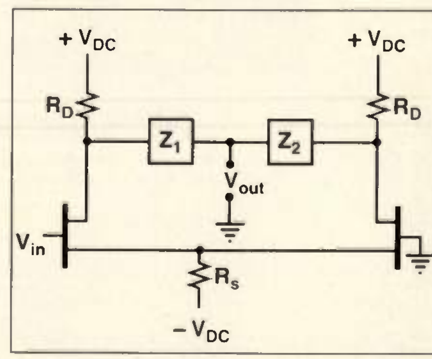


**Figure 13. Push-pull source using a long-tail pair**

### About the Author

Robert Dehoney received his BSEE from MIT in 1950. After graduation, he worked for the Allen B DuMont Labs designing RF equipment for UHF TV. He retired from Fairchild Weston in 1987 as a Technical Director in ECM. He is now a private consultant. He can be reached at 4602 Palm Blvd., Isle of Palms, SC 29451, or by phone at (803)-886-5785.

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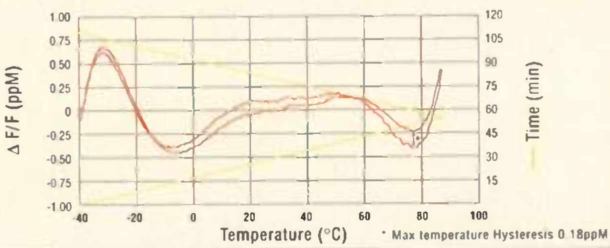


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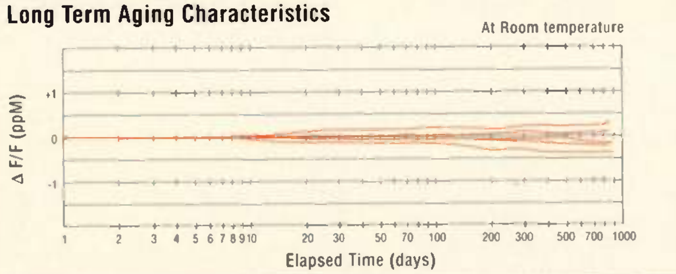


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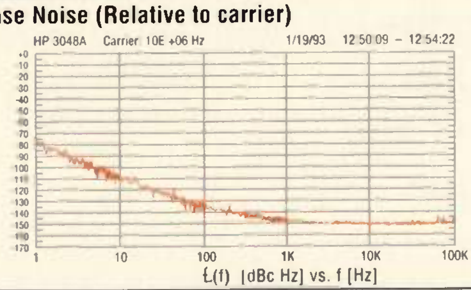



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INFO/CARD 48

# Shielding Products Makers Wait for Electronic Industry to Focus

By Ann Marie Trudeau
Assistant Editor

Shielding products, the items that are needed if engineers can't design out radio frequency interference (RFI), are in a market that seems to be unfocused for the future. The market itself is growing for a number of reasons but what is unstable is the wait to see how U.S. electronic manufacturers are going to respond to the various market choices and forces that are now in motion. What may be the largest force for the immediate future is the European Community's tightening of their RFI regulations which unlike the U.S. regulations includes susceptibility requirements for electronic equipment.

As the only American observer on the European EMC Information Technology committee (EMCIT) for the last four years Gary Fenical has developed strong opinions. Fenical is Manager of EMC at Instruments Specialties Co., Inc. and is the informal liasion between the committee and the registered test labs in the United States.

Fenical pointed out that some in the industry are taking a wait and see attitude while others are acting as if the Europeans are not going to actually impliment stronger requirements. "Well, it's too late already," Fenical said, "because at the first of January 1996 all electronic or electrical equipment must comply, no ifs, ands or buts; no grandfathering. The ones that have not done anything or are just starting are in trouble." He also pointed out that if you sell new piece of equipment in Europe and there Europe has a requirement change the manufacturer will be given time to comply. You don't have to retrofit but there's no grandfathering now or in the future. That isn't how it happens in the U.S. But, however the industry responds the FCC has responded to the European rules. Fenical said that it's now offical that ay equipment complient with the Euripean reles and regulations will be honored here in the U.S. But, he also observed that the reverse wasn't true.

In addition to concerns about how Europe may affect the industry some companies are also dealing with entering the commercial market after having been heavily involved with the military.

James L. Pean, Corporate Communication Manager of Tecknit said that the military followed TEMPEST regulations. These are the standards where electronic equipment would survive the electronic pulse from an atomic bomb. So now the industry is also having to deal with requirements that are not as strict to get into the commerical markets. He also sees the choices that are available to the market for expansion are the third world countries that are literally rewiring their communications systems; countries like Vietnam and Russia.

**...some in the industry are taking a wait and see attitude**

The part of the market that doesn't seem to be worried about the time frame to meet changing regulations is the injection molding part of the shielding industry. Ralph Starkey, Sales Manager of Windsor Plastics, said that they could respond in about six to nine months to stricter regulations. He also sees that even though engineers eventually design out the need for shielding the increase in clock speeds are ahead of those efforts so shielding needs will be driven by the delayed response of designers to the market demand. Bill Stratton, Marketing Manager for Electronics for Adhesives Research, said that design problems do show up because of customer expectations. The person in an airplane who is using a notebook computer and a cellular phone at the same time has the computer wiped out. "You have to make sure one system doesn't affect the others," Stratton said.

Instrument Specialties is gearing to use finite element analysis (FEA), a computer technique, to evaluate designs before building a prototype. "You can test drive it without taking it out of the showroom," Tony Sosnowski, Product Line Manager said. He said that their Ultra-Flex™ was a result of just such a product analaysis and now it's patented.

But also the market seems to be growing even without focusing on the changes in Europe. "We believe the market for EMI pressure sensitive tapes is probably about $10 million for just the U.S. market," Stratton, said. "That's not for the future, that's now."

He said that the ability of Adhesives Research to come up with their Flexshield™ helped them in the space satellite market. In the satellite business weight is a major factor because for every one pound over the design weight it costs an extra $18,000 and that is why their product was used to replace aluminum foil tape shielding.

Some people in the industry may not have to respond with an either/or approach. Bob Barlow, Business Director for the Matalized Mterials Business of Monsanto Chemicals, said that the European changes may give Europe a marketing advantage, but that there may be enough differences between the markets in other areas that would make it feasible for a U.S. company to make a separate product for each market.

## Summary

The shielding products manufacturersis are in a good place. The drive for faster clock speeds to meet demands and the inability of engineers to keep up with designing out all RFI before the products hit the market, the growing third world markets, and traditional markets keep them in business. The big gussing game is how the electronic industry is going to respond the European changes. *RF*

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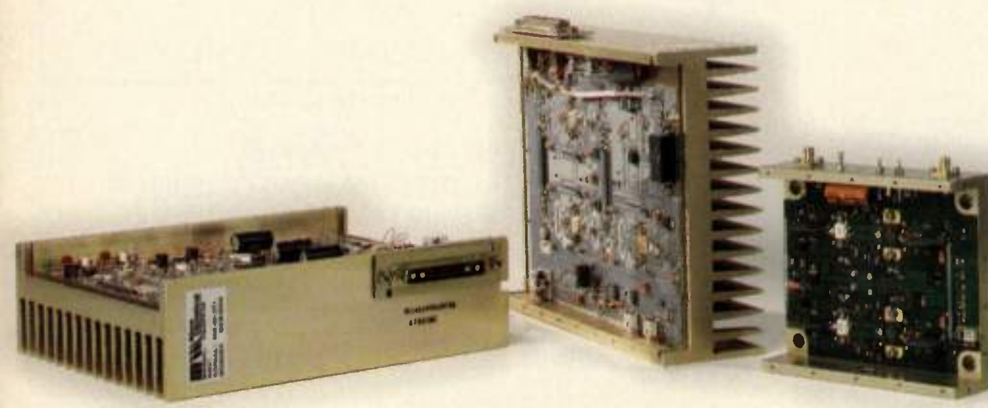

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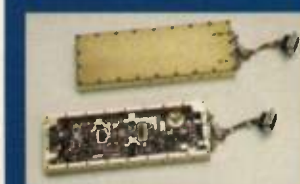

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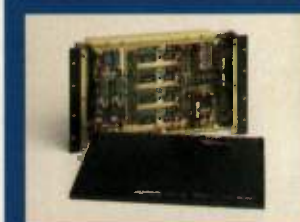

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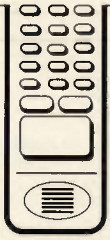

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# RF software

## Digital Modulation Simulation

Tektronix has released the latest version of IQSIM, an MS-DOS software package developed by Rhode & Schwarz that simulates digital modulation standards such as GSM, DECT, CT-2, PHP and PCS. IQSIM also allows the generation of digital signals with custom combinations of coding, filtering and modulation. The software can be used with the Rhode & Schwarz ADS arbitrary waveform generator and SMHU.58 signal generator. IQSIM comes standard with the ADS waveform generator, which is priced at $14,210.
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## Inductance, Resistance and Current Solver

A new multi-plane inductance, resistance and current solver from the CAE Division of Contec Microelectronics allows designers to solve planar structures with greater accuracy and speed than alternative solutions. The geometries to be studied by ContecPLANE can be entered textually or can be imported from AutoCAD™ DXF files. ContecPLANE outputs current distribution plots and reduced n-port SPICE sub-circuit models. The program is available now in versions for the Sun SPARCStations and HP9000 Series 700 workstations. Licenses for the stand-alone version of ContecPLANE start at $15,000.
**Contec Microelectronics U.S.A.**
**INFO/CARD #198**

## Coverage Prediction

EDX Engineering has released version 1.2 of MCS™. This IBM-PC compatible program predicts multipath degradation of digital broadcast signals. It can explicitly take into account reflections from buildings and other surfaces to model the amount of digital pulse distortion or "spread" which directly lead to bit errors in the digital signal.
**EDX Engineering, Inc.**
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## Schematic Capture/Copper Pour for AutoCAD

CAD Design Services is an authorized third party developer of software for AutoCAD. Their schematic capture software generates parts lists and net lists in varied formats. Gerb2CAD brings any Gerber file into AutoCAD, and the user can pour copper or produce Gerber ouput with GerbArt.
**CAD Design Services, Inc.**
**INFO/CARD #196**

# RF advertising index


| ADVERTISER | PAGE # |
|---|---|
| Ameritron | 46 |
| Amplifier Research | 10 |
| Analog and RF Models | 60 |
| Arrowsmith Shelburne | 50 |
| Bal Seal Engineering | 51 |
| Cad Design Services | 65 |
| Cal Crystal Lab., Inc | 61 |
| California Eastern Labs | 35 |
| Compact Software | 24-25 |
| Comtronix | 60 |
| Daico Industries | 6 |
| Eagle | 41 |
| Eagleware | 65 |
| Electro Dynamic Crystal | 30 |
| Emhiser Research | 55 |
| Equipto Electronics Corp. | 67 |
| Gallagher & Associates | 60 |
| Giga-tronics Inc. | 12-13 |
| Henry Radio | 46 |
| Hewlett Packard MCG Marcom | 29 |
| IEEE – EMC | 66 |
| IFR Systems Inc. | 3 |
| Int'l Crystal Mfg. | 37, 65 |
| Jan Crystals | 41 |
| JFW Industries | 47 |
| Kalmus Engineering | 9 |
| KS Electronics | 60 |
| Locus, Inc. | 61 |
| M/A Com (3 Divisions) | 70 |
| Micro Communications Executive Search | 60 |
| Milcom | 59 |
| Mini Circuits | 2, 4-5, 45, 49 |
| Motorola | 62 |
| Nova Engineering, Inc. | 14 |
| Nova RF Systems, Inc. | 61 |
| Odetics | 31 |
| Pacific Communication Sciences Inc. | 61 |
| Penstock, Inc. | 11, 53 |
| Power Systems Technology | 69 |
| Programmed Test Sources | 27 |
| Q-Bit Corp. | 30 |
| Qualcomm | 20 |
| Rakon | 57 |
| Raltron Electronics Corp. | 51 |
| Ramsey | 61 |
| RF Power Systems | 60 |
| Richardson Electronics | 15, 17, 19, 21 |
| Rogers Corporation | 33 |
| Silicon Valley Power Amps | 36 |
| Sprague Goodman Electronics | 43 |
| Synergy Microwave | 23 |
| Temex Electronics | 16 |
| Tesoft, Inc. | 63 |
| Toko America, Inc. | 32 |
| Vectron Labs, Inc. | 37 |
| Werlatone, Inc. | 8 |
| Wide Band Engineering Co., Inc. | 39 |

# RF literature

## Test, Measurement Catalog
Tektronix's 1994 catalog provides comprehensive test and measurement product specification information for electronic users in digital design, general purpose, telecommunications, television , industrial, and semiconductor markets. Also listed are Advantest RF microwave and telecommunications products and Rohde & Schwarz test and measurement instruments as Tektronix is their sole distributor in North America.
**Textronix**
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## Capabilities Brochure
This brochure features Taconic Plastics, Ltd. copper clad, PTFEwoven glass substrates. They also offer TLY, TLT, TLX, TLC, and TLE laminated lines. Their products are used by various commercial and military microwave systems including phased array antennas, mobile communication, radar systems, microwave test equipment and transmission devices and RF components.
**Taconic Plastics, Ltd.**
**INFO/CARD #201**

## SPICE Newsletter
Intusoft's free February newsletter covers SPICE circuit simulation programs that model photodiodes and vacum tubes. The tubes' subcircuits include vacuum triode and pentode models and provides models for the 12AU7A and EL9000. Two models of photodiodes are presented; one for a specific part (Siemens BPW34).
**Intusoft**
**INFO/CARD #202**

## Cellular Filter Data Sheet
K & L Microwave Incorporated offers a two page data sheet featuring specifications, plots and mechanical drawings for the K & L model #9FVSP-836.5/25 cellular bandpass filter.
**K & L Incorporated**
**INFO/CARD #203**

## Low Noise Oscillators
A six page brochure gives detailed specifications on Vari-L Company, Inc.'s new VCO-190 series of 5 volt 10 mA surface mount low noise voltage controlled oscillators. Noise, power and modulation sensitivity plots are provided as well as detailed pachage and installlation information. Thirty-five robotically assembled models are described for wireless designs spannning 45 to 3000 MHz. Devices with separate modulation ports are also described.
**Vari-L Company**
**INFO/CARD #204**

## RF Product Catalog
Microelectronics's free 78-page catalog lists all their RF and Microwave capacitors.
**Microelectronics Ltd.**
**INFO/CARD #205**

## Passive Components Catalog
Trilithic's new 93 page 1994 catalog details specifications and outline drawings on a variety of passive components in the frequency range of DC to 18 GHz.Components in cluded are fixed and tunable filters; fixed, high-power, programmable, and variable attenuators; high-power loads; SPDT, SP4T, and SP8T programmable switches; and built-to order switching and control rack-mountable subsystems.
**Trilithic**
**INFO/CARD #206**

## Filter Application Note
Webb Laboratories' four page application note demonstrates advanced capabilities of the AFDPLUS active filter design software. A Multi-octave 90 degree phase splitting network is designed and analyzed taking advantage of the user-defined pole/zero location files, transfer function math, macro and graphics capabilities incorporated with the AFDPLUS environment.
**Webb Laboratories**
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## EMC Accessories Catalog
A new 24-page free catalog from Hewlett-Packard describes transducers, antennas, preamplifiers and other electromgnetic compatibility (EMC) accessories that design engineers and test technicians need to evaluate their product design, or to equip a lab for conducted and radiated emissions compliance testing. It also includes an application guide for commercial and military measurements.
**Hewlett-Packard Company**
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## HP Microwave Test Catalog
An updated version of Hewlett-Packard's Microwave Test Accessories Catalog includes 1000 products for testing and characterizing components. The 88-page catalog is free
**Hewlett-Packard Company**
**INFO/CARD #209**

## Pulse Generator Catalog
Avtech Electrosystems has introduced a new 16-page Update Catalog No. 8S2 which describes recently introduced hig-speed pulse generators and laser diode drivers. Attention is given to DC to 10 MHz laser diode drivers, 10 MHz to 1.5 GHz laser diode bias tee modulation heads, 100 volt, 1MHz lab pulse generators.
**Avtech Electrosystems Ltd.**
**INFO/CARD #210**

## Electronic Control Brochure
Eaton Corporation highlights is offering a capabilities brochure which includes products for space vehicles, weapon systems, communications, and computer equipment.
**Eaton Corporation**
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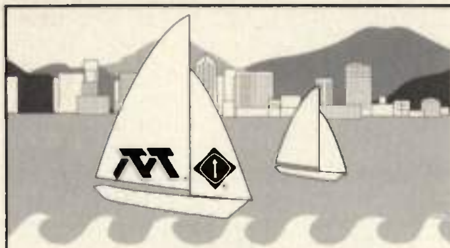
# RF company index

**A list of companies and institutions mentioned in this issue's editorial pages**

| | |
|---|---|
| Analog Devices | 37, 42 |
| Analogic Corp. | 44 |
| Andrew Corp. | 43 |
| AT&T | 22, 34 |
| Avtech Electrosystems | 64 |
| CAD Design Services | 63 |
| Cellular One | 22 |
| Contec Microelectronics | 63 |
| Cubic Corporation | 20 |
| Eaton Corporation | 64 |
| EDX Engineering, Inc. | 63 |
| EIP Microwave | 44 |
| ENI | 44 |
| Fil-Mag, Inc. | 20 |
| Flam & Russell | 18 |
| Frost & Sullivan | 18 |
| Harris Broadcast | 22 |
| Hewlett-Packard Co. | 37, 64 |
| Hitachi | 36 |
| Huber+Suhner AG | 43 |
| Hyperl;abs, Inc. | 44 |
| Insulated Wire, Inc. | 43 |
| International Telecommunications Union | 18 |
| Intusoft | 64 |
| ISRO Space Applications Centre | 63 |
| ITT GTC | 34 |
| Johnstech International | 18 |
| Jones Intercable | 22 |
| K&L Inc. | 64 |
| Kilovac Corp. | 46 |
| KW Microwave | 46 |
| Leica Inc. | 18 |
| LPKF CAD/CAM Systems | 20 |
| Magnavox Electronic Systems | 18 |
| Merrimac Industries | 44 |
| Microelectronics Ltd. | 64 |
| MIL-3, Inc. | 22 |
| Milliren Technologies | 43 |
| Mini-Circuits | 44 |
| Mitsubishi Electronics America., Inc. | 44 |
| Monsanto Metalized Materials | 20 |
| Motorola Cellular | 18 |
| Motorola Semiconductor | 36, 44 |
| NIST | 18 |
| Noise Com | 22 |
| North American Capacitor Company | 20 |
| Novatech instruments | 43 |
| Oxley Development Co. | 20 |
| Phoenix Microwave Corp. | 44 |
| Piezo Technology Inc. | 42 |
| Pole Zero Corp. | 42 |
| Polyflon Company | 18 |
| Raltron Electronics Corp. | 46 |
| Raytheon Semiconductor | 18 |
| Rohde & Schwarz | 18 |
| RF Industries Ltd. | 43 |
| RF Power Systems | 44 |
| Shawinigan Research & Technology | 18 |
| Softwright, LLC | 22 |
| Sonnet Software | 20 |
| Stanford Research Systems | 42 |
| Superconductivity, inc. | 18 |
| Svetlana Electron Devices | 44 |
| Taconic Plastics | 64 |
| Technitrol, Inc. | 20 |
| Tektronix | 18, 63, 64 |
| Telecom Analysis Systems | 43 |
| Teledyne Electronic Technologies | 22 |
| Tele-Quartz GmbH | 43 |
| Temic Telefunken Microelectronics | 36 |
| Tesoft | 22 |
| Trilithic | 64 |
| Tru-Connector Corp. | 43 |
| TriQuint Semiconductor | 34 |
| Wavetek | 22 |
| Vari-L | 42, 64 |
| Veritech Microwave, Inc. | 44 |
| Virginia Polytechnic Institute & State Univ. | 22 |
| Voltronics International | 46 |
| Webb Laboratories | 64 |
| Wiltron Company | 38 |
| Zenith Electronics | 18 |



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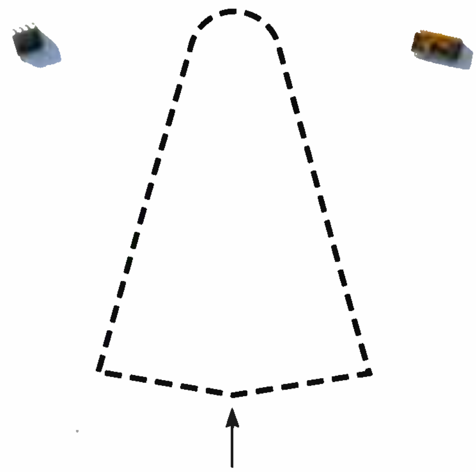

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